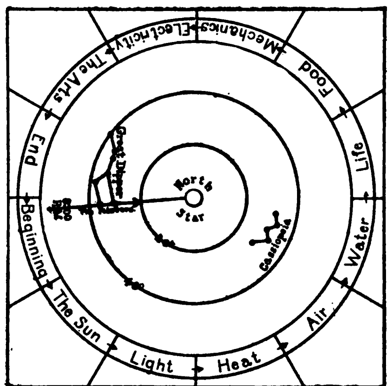
SCIENCE

FOR THE

FIFTH GRADE

ROWELL

THE GUIDE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THE GUIDE

SCIENCE

FOR THE

FIFTH GRADE

WITH EXPERIMENTS

BY

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PREFACE.

This book, the first of a series of four, is written upon the basis that all science must rest upon the broad foundations of general knowledge. Many of the difficulties which have beset science teaching in the grades have been due to the fact that only a small field of science has been taught, and that the field has been too minutely studied. To confine the child of a lower grade to a study of a single group of phenomena, just because he is young, is to deprive him of natural opportunities of learning. There is no reason why all branches of science cannot be learned by children, if the beginnings are but presented according to their way of thinking. General knowledge is not necessarily superficial.

The science which is most valuable to the child is that which explains the phenomena of the environment—the science of common things—the science of everyday life. No one branch of science can do this, nor can any one branch of science be properly taught without doing it. A blending of all branches of science, as a means for the best teaching of it in the grades, is inevitable.

The teaching of science in the grades has been handicapped by the supposed necessity for elaborate and costly apparatus. Few of the experiments in this text require even the cheaper apparatus, while most of them do not require anything which really should be called apparatus. The use of common things to illustrate scientific truths

has also the decided advantage of bringing the science home to the child. He repeats his experiments at home, for he has the "apparatus", and the science becomes his, through the reproduction.

The experiments, although very simple, do not merely verify the statements of the text, but they elaborate and add to it. They are often the source of information, and thus the pupils become imbued with the desire for investigation—the true scientific spirit. To obtain the best results the pupils should write up their experiments in brief manner and illustrate their work with simple drawings of the apparatus and objects which have been used.

There has been no attempt at an exhaustive study of any one thing. Many of the sections could be enlarged to produce a book in themselves. The attempt has been made, however, to show the balance which exists between vegetable and animal life, and the underlying principles which govern all animate as well as all inanimate existence. If the conditions are such as to warrant the special and more comprehensive study of any of the sections, the List for Teachers, which the United States Department of Agriculture has prepared, should be consulted. This list covers a vast field, not alone from the agricultural standpoint, but from that of general science.

The work is cumulative, always building upon the old and constantly making use of it. Often the foundations for a section are laid many sections before, and thus the science lessons become one whole, a complete blending of the different parts being accomplished naturally, and without apparent effort on the part of the teacher or pupils.

Teaching the applications of science to the industries and the arts will give the pupils the first insight into their own desires and capabilities. They will thus begin unconsciously to prepare themselves along the line of prevocational work. Later they will also realize the dignity of labor, and the science teaching may easily develop into the various branches of vocational work, and the pupils may be given the rare opportunity of viewing the field of human endeavor and of truly choosing their career in life.

Many new texts and other publications have been freely consulted in the preparation of this book. Since much of the material has become common property, specific acknowledgment has not been made, but the author takes this opportunity of thanking the many publishers who have so kindly supplied him with reference books.

Especial thanks are due Mr. James B. Davidson, Superintendent of Schools of Marin County, California, and Mr. David R. Jones, City Superintendent of Schools of San Rafael, California, both of whom have read the manuscript and have given to the book the benefit of their experience. Thanks are also due Messrs Boggs, Davalos, and Persell who made many of the drawings. Acknowledgement is made through the text for other special obligations. The author alone is responsible for any mistakes which may have crept into the work.

PERCY ELLIOTT ROWELL.

Berkeley, California.
July, 1913

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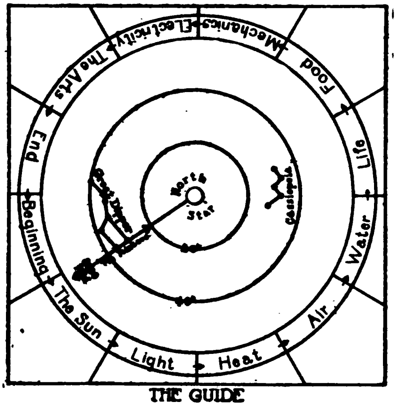

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SCIENCE FOR THE FIFTH GRADE

THE SUN, STARS, AND PLANETS.

1. Time of Sunrise and Sunset.

Did you see the sun rise this morning? Was it too early for you? Does the sun always rise before you do? What time did the sun set last night? Does the sun always set at that time? Watch the time of sunrise and sunset for several days and keep a record of your results.

The days are longer in summer than in winter because the sun rises earlier and sets later than in winter. The longest day of the year is June 21 and the shortest day is December 21. On two days of the year the sun rises at six o'clock in the morning and sets at six o'clock in the evening. These two days are half way between June 21 and December 21. Count the days on a calendar and tell what are the dates of these two days. These days are called the **Equinoxes,** meaning equal nights.

You will discover, if you keep a record of the time of sunrise and sunset, that the sun always rises as much before noontime as it sets after noontime. See Experiment 3. Thus the forenoon and the afternoon are of the same length. What can you say of the number of hours between sunset and midnight and the number of hours between midnight and sunrise?

2. Experiments.

We can learn from teachers and from books or we

can learn from the things themselves. All of our knowledge comes from experience with the actual things which have been studied in the past by those who have written books about them. The use of books, then, saves time for we can read in a few minutes the results of years of study. Our teachers also can help us very much because they have learned from other books, from other teachers, and from things. Wherever it is possible we should study things. We may forget what the books say and what the teacher has said, but we can easily remember what we ourselves have done. Whenever we try to discover from the thing itself how it acts, we are performing an experiment.

The best way in which to learn science is by means of experiments, because science is a study of how everything acts and why it acts as it does. We may not have our books with us always, and if we can discover from the things themselves what we want to know we shall become independent, and learn without help from books or from teachers. There are many studies which must be learned from books but science is an exception. The record which you are keeping of the time of sunrise and sunset is an experiment. The value of experiments, then, is that we can learn from the very thing what we want to know.

3. Direction. The North.

Sometimes it is important to know in what direction you should go in order to arrive at a certain place. In cities and towns the direction can be easily learned from the streets. We are directed to go a certain number of blocks one way and then a certain number of blocks an-

other way. On the ocean and in the open country, however, where there are no roads, we must depend upon some other method of finding our way. One method is by means of a star which is so nearly in the north that it is called the **North Star.**

Among all the stars which brighten the sky at night, it would be very hard to find the North Star if there were not a huge sign in the sky which always points to it. This sign is called the **Great Dipper.** The two stars which are the farthest from the handle are called the "pointers" because they point to the North Star. Let us try to locate the north by the North Star. To do this we shall perform an experiment.

Experiment 1.—To Locate the North by Means of the North Star.

Materials: Two straight sticks, string.

a. Look in the sky until you find the Great Dipper Then glance from one "pointer" past the other "pointer" until your glance has gone beyond it five times the distance between the two pointers. There you will see the North Star. When you look at this star you are looking almost exactly north.

b. If we did not make some record of the direction of the North Star we should be unable next day to tell exactly where the north is. To make a record we need two sticks. Drive one stick into the ground in a place from which the North Star is visible. Then go south from this stick about five feet and drive the second stick into the ground in such a position that by looking just past its edge, you can see the North Star just past the edge of the first stick. The two sticks are said to be **in**

line with the North Star, because if a line were drawn from one stick to the other, and then extended far enough it would pass to the North Star. A string stretched between the two sticks forms a line which points north.

Review Questions, 1.

1. When did the sun rise this morning?
2. How can you tell the time of sunrise by the time of sunset?
3. Why are books valuable?
4. What is an experiment?
5. What are some of the advantages of performing experiments?
6. When should we use books and when should we experiment?
7. How do those who write books learn what to write?
8. How do we direct persons from one place to another, in a city?
9. What must we do in the open country, or on the ocean, to know in what direction we are going?
10. Why did you drive two sticks in the ground to make a line pointing north? Could you have done it with one stick?

Experiment 2.—*The Movement of the Great Dipper.

Apparatus: Rule, scissors, dividers.

Materials: Cardboard 6″x12″, paper fastener, or pin and piece of cork.

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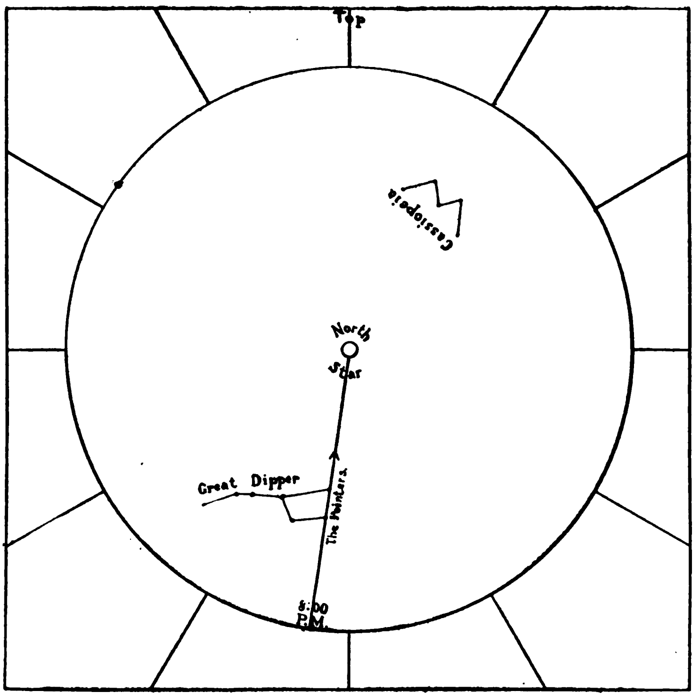
* See Section 62 before performing this experiment

a. Cut the cardboard into two squares 6″x6″ and find the center of each piece. To do this lay the rule upon the cardboard so that it crosses it and touches two corners. Make a short line near the center and repeat for the other two corners. Where the two lines meet is the center. Open your dividers so that the points are two and one-half inches apart; place one point upon the center of one piece of cardboard and draw a circle. Upon



this circle draw the Great Dipper and Cassiopeia, as shown in the illustration, and fasten it by means of a paper fastener, or a pin pushed through the centers into a piece of cork.

b. Hold the apparatus so that you must look toward the north in order to see it. Turn the circular piece so that the Great Dipper is in the position in which you saw those stars at eight o'clock last night, and mark with the date the square piece of cardboard where the line comes which passes through the "pointers."

c. Look at the Great Dipper at seven o'clock and at nine o'clock. Does it move in the same direction as the hands of a clock or in the other direction?

d. Look at the Great Dipper once a week for a few weeks, and then once a month, always at eight o'clock, and mark the square piece with the date. See how much of the way around the North Star the Great Dipper goes in one month and then tell where you think the Great Dipper will be in six months.

Experiment 3.—To Locate the North by Means of Shadows.

Apparatus: Long nail, board.

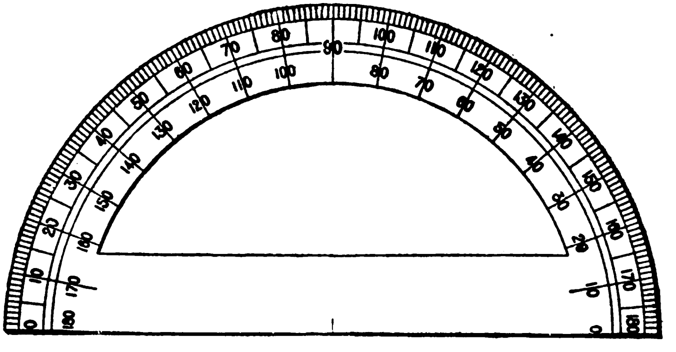
a. Drive the nail into a level board placed where the sun will shine upon it all day. Mark along the shadow of the nail at nine, ten, and eleven o'clock, in the morning, and at one, two, and three o'clock in the afternoon. Half-way between the shadows which were cast at nine o'clock and three o'clock is north. Half-way between the shadows cast at ten o'clock and two o'clock also is north. The same is true of the other two shadows. Can you discover some rule in regard to the directions of

shadows in the forenoon and in the afternoon? Why do you think so many shadows were marked? What would you do if part of the day were cloudy?

The north side of trees has the most moss, as a rule, because that side receives the least sunshine and is the wettest. Since moss requires a large amount of moisture it cannot live on the sunny side of trees, unless there is a great deal of rain.

4. Circular Measurement.

If you stand in one place and turn around until you face the same way as you did before you began to move, you have made one revolution, or a complete circle. If someone told you to turn one-half or one-quarter the way around you would know how far to turn. Perhaps you could turn one-eighth the way around. If someone wanted you to turn one-sixteenth the way around you probably would not know how far to turn. In order to



measure any part of a revolution, or a circle, it has been divided into 360 parts called **degrees.** A degree means a step. The number 360 was chosen because it can be divided evenly by so many numbers. See if it can be divided by 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. Try dividing 360 by other numbers. A semi-circle divided into 180 degrees is called a **protractor.** It is used to measure the part of a revolution, or circle, which one direction turns from another direction. The short and proper way of writing "degrees" is to use a little circle after the number. For example, 75 degrees may be written 75°. This means 75 parts of a circle.

5. Other Directions.

If you face the north, the south is behind you; the east is at your right and the west is at your left. These four points of direction are each a quarter of a revolution, or a quarter of a circle, from the next one. How many degrees between any two of them? How many degrees between the north and the south. If one direction is 180 dgrees from another direction the two directions are said to be **opposite** each other. Is the east opposite to the west? Why?

Experiment 4.—To Locate the South by Means of a Watch.

a. Hold the watch so that the hour hand points toward the sun. The south direction will then be just half way between the hour hand and the figure XII on the watch. Do this both in the morning and afternoon and see if the result is the same. Can you tell where the north is from this experiment?

These four directions, north, south, east, and west

are not enough for even ordinary use, so the half-way points are named according to the directions between which they come. The directions north and south are named first, thus: North-east, north-west, south-east, and south-west. How many degrees are there between north-east and east? Between north-east and north-west? Between south-east and south-west?

Review Questions, 2.

1. Make a drawing of the Great Dipper as it was the last time you saw it, and write the date and hour when you saw it.

2. How often does the Great Dipper seem to go around the North Star?

3. Which side of the house is the driest, the north side or the south side? Why?

4. Is it better to answer the last question after noticing the rooms of a house, or to find the answer in some book?

5. How many degrees are there in half a circle? In a quarter of a circle? If you are walking along a

street and turn into a side street, how many degrees do you turn?

6. What is a protractor? For what is it used?

7. If you face the south, where is the east? The west?

8. If you are facing east, how much must you turn in order to face north? Would you turn toward the left or toward the right?

6. The Direction of Sunrise and Sunset

Where did the sun rise this morning? Where did it set last night? Does the sun always rise in the same place? Does it always set in the same place? Where would the shadow of a stick point at sunrise? Where at noon? Where at sunset? An experiment is the best way of answering these questions.

Experiment 5.—*The Direction of Sunrise and Sunset by Shadows.

Apparatus: Hatpin, protractor.

a. Stick a hatpin into the North-South line which you determined in Experiment 1, or in Experiment 3. Mark its shadow at sunrise and at sunset. Place the straight side of the protractor along the North-South line, with its center mark at the hatpin, and tell how many degrees the direction of sunrise is from the North-South line. Repeat for the direction of sunset. The direction of sunset is as much away from the south direction as is the direction of sunrise. See if this is the same after a few days. If this is true we can learn the direction of sunrise by knowing the direction of sunset.

* This experiment can be performed only at home.

The position of the sun varies from day to day, the sun being farther to the south in winter than in summer. The sun rises in the east and sets in the west on two days only. What are those days? How can you find out?

Experiment 6.—*To Record the Direction of Sunset.

a. Use the apparatus of Experiment 5. and arrange your results in the form of a table. Direction should always be measured from the North-South line whenever we wish to be exact. If the direction is just east or just west, we say so. All other directions are given as the number of degrees they are from the north toward the east or west, and from the south toward the east or west. If the direction of sunset is 80 degrees from the north, the record should be: N. 80° W. If it is 70 degrees from the south, the record should be: S. 70° W. What is the difference between N. 90°W. and S.90° W?

b. The table for the record should be as follows:

Date				
Direction				

Once a week is often enough to take the observations. Try it at home and see how your results compare with those of the other pupils.

Review Questions. 3.

1. Begin with the direction north, and name the four principal directions, and the half-way directions, all the way around the circle, starting toward the east Now repeat starting toward the west.

2. Where did the sun rise this morning?

* This experiment can be performed only at home.

3. How can you tell the direction of sunrise by knowing the direction of sunset?

4. On what days does the sun rise at six o'clock and set at six o'clock?

5. How can you tell when it is noon by a shadow?

6. How can you tell where the north is by a shadow?

7. If the sun sets S. 85° W. where does it rise? Make a drawing of this, using the protractor, and obtain your answer from the drawing.

8. If the sun sets N. 80° W. where does it rise? Make a drawing as in the previous question.

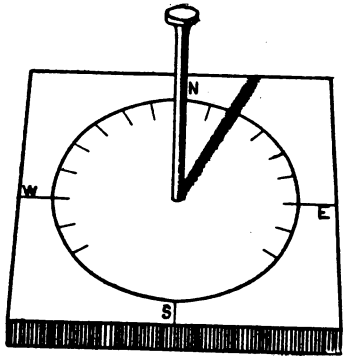
7. Telling Time by the Sun.

In olden times, before clocks were made, people used to tell time by the sun. Even now there are many persons who can judge the time very nearly, by the position of the sun in the sky. Yet it is impossible to learn the time from the sun, with exactness, unless we make use of a simple piece of apparatus. Just a stick driven into the ground is all that is necessary. When the shadow points north it is noon. See Experiment 3. When the shadows cast at sunrise and sunset are opposite each other the time of each is six o'clock. If the semi-circle on the north side of the stick is divided into twelve equal parts, the shadow will take one hour to pass over each part. These divisions may be marked with the hours between six in the morning and six at night. Over how many degrees does the shadow move in one hour?

Experiment 7.—The Sundial.

Apparatus: Board, protractor, nail.

a. Draw a circle on a board using the protractor, and divide it into 24 equal parts. How many degrees are there in each part? Drive a nail into its center so that it makes an angle of 90° with the board, in all directions. You can do this by holding your protractor against the nail as you drive it. Draw a line from

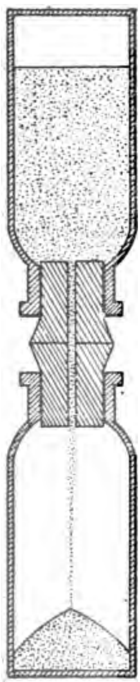


the nail lengthwise of the board and place the board so that this line runs north and south. How can you do this? Mark this line 12, where it crosses the circle on the north side, and then mark the other divisions properly Is there any need to mark all of the divisions? Why? What time does the shadow tell in the illustration?

8. Other Ways of Telling Time.

The sundial is a good way of telling time on sunny days, but if we want to know the time when the sun is not shining we must use other methods. Long ago the sand-glass, or hour-glass was invented to tell the length of an hour. This was made by connecting two bulbs or globes by means of a small tube and having one globe filled with sand. The filled globe was placed on top and the sand slipped slowly through the small hole into the lower globe. When all the sand had left the upper globe an hour had passed. Then the hour-glass was turned upside down and a record was kept of the number of hours. Why was the name hour-glass given?

An ingenious scheme of telling time was by means of water. Water was placed in a tank and allowed to flow out through a small hole into a little tank where there was a float made of wood. As the water rose the float rose and indicated the hours by marks on the side of the little tank. Nowadays clocks are used in which wheels are allowed to turn slowly by means of a pendulum. See Section 64. Next year we shall study more about clocks.



Experiment 8.—The Sand-glass.

Apparatus: Two small bottles, two stoppers, a piece of glass tubing ⅛″ diameter, small triangular file, fine sand.

a. Bore a hole in the two stoppers for the glass tube and insert the tube in the stoppers with their tops together. The tube should not extend beyond the stoppers. Fill one bottle with fine, dry sand, insert the stoppers into the bottles and the sand-glass is finished.

b. How long does it take for the sand to run through? Keep changing the amount of sand until it takes exactly one minute, or exactly two minutes for the sand to run through. Is this an hour-glass? A sand-glass made like this and which would run for three and a half or four minutes would be useful for timing the boiling of eggs.

9. The Height of the Sun at Noon.

When is the sun highest in the sky? If the sun is in line with the surface of the earth at sunrise, and gradually becomes higher then gradually becomes lower until at sunset it is again in line with the surface of the earth, the highest point must have been reached halfway between sunrise and sunset. What time is this? What can you say about the length of shadows at sunrise and at noon? At sunset and at noon? When is the shortest shadow? Is the length of a shadow at noon always the same? If you do not know, how are you going to find out? The varying length of a shadow shows the height of the sun.

Experiment 9.—The Height of the Sun at Noon by Means of a Shadow.

a. Measure the length of the shadow of a window-sill at noon today.

b. One week later measure it again. Is it the same? Continue to measure the shadow once a week, keeping a record of the lengths similar to the record used in Experiment 6. Later you will have some questions about this experiment to answer. See Section 69

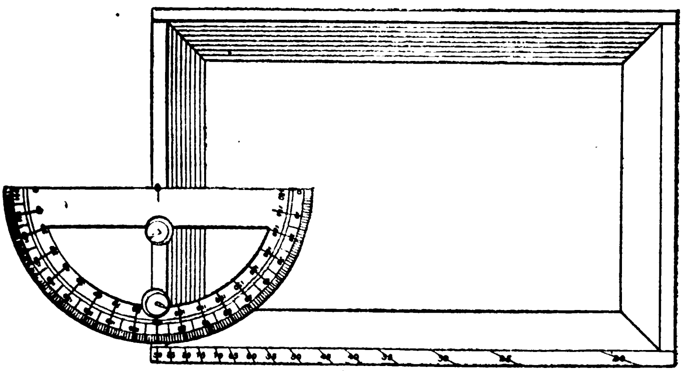
We can measure the height of trees and buildings and mountains in feet and inches but we cannot measure the height of the sun in this manner. We always measure the height of the sun and stars by the number of degrees which we have to look upward from the surface of the ocean or a lake. We call looking along the surface of

a body of water zero degrees high. We call directly overhead ninety degrees high.

Experiment 10.—The Height of the Sun at Noon Measured in Degrees.

Apparatus: Chalk box, protractor, nail, two tacks.

a. Take an empty chalk box and with the open side toward you tack the protractor so that its straight side crosses the short end of the box half-way and is parallel with the long side. Drive a brad at the center point of the protractor. With your rule held against the brad and over the 85 division, mark the edge of the box with pencil. Repeat for each 5°. The marks on the edge of the chalk box are not the same distance apart, but a shadow of the nail falls on each mark in succession for each 5°. See if this is not true. The apparatus should appear like the illustration.



b. Place the box so that the shadow of the nail at noon falls across the protractor and on the edge of the

box. What is the number of degrees that the sun is high at noon? Repeat once a week and keep a record as in the last experiment. Do you think that the sun is ever overhead? Can you find out?

Review Questions, 4.

1. Name four ways of telling time.

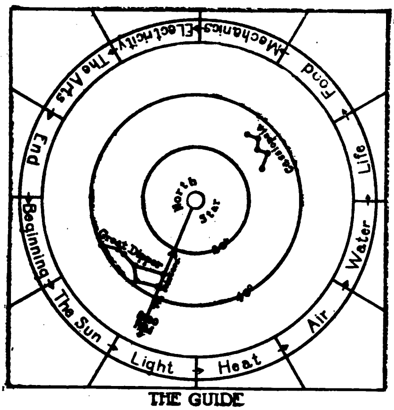
2. When did the sun set last night? Then when did the sun rise yesterday?

3. If the hole in the tube of the hour-glass were smaller would it make any difference in the time which it would take for the sand to run through?

4. When is the sun the highest in the sky? How can you tell?

5. What are the two ways of stating how high the sun is?

Next year you will learn more concerning the sun, stars, and planets. Now we are going to study about what we receive from the sun.



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LIGHT

10. The Light We Receive from the Sun.

Just after sunrise and just before sunset we may look at the sun without hurting our eyes. The sun looks large and red. The reason it looks large is because we can compare its size with the size of other objects, and when we notice that it appears larger than a distant house or tree we realize that it is very large. The sun appears red because the light in coming along the surface of the earth has passed through a large amount of dust and fine drops of water, which have sifted the light until most of its strength has been taken out.

As the sun mounts higher and higher in the sky, the light passes through less and less of the fine particles, and we say the light becomes brighter. On hazy days, or when there is smoke in the air, the sun looks red even at noontime. To show that the reason why the sun appears red is because the light is sifted, we can perform the following experiment.

Experiment 11.—The Appearance of the Sun through Smoked Glass.

Apparatus: Glass, candle.

a. Hold a piece of ordinary window glass in the flame of a candle or the flame of a kerosene lamp, moving the glass around in order to distribute the smoke. If the glass is held still in the flame it will break. Smoke one side only. The material on the glass is soot.

b. Hold the smoked glass between the sun and one of your eyes, closing the other one. How does the sun appear? Move the glass so that you look through more

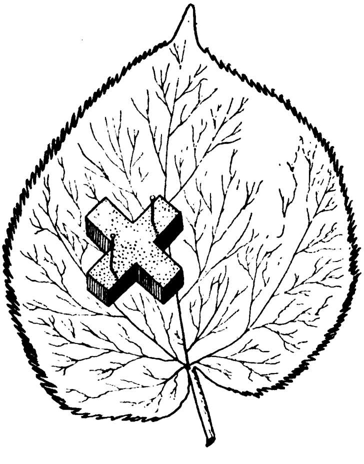
or less soot. How does the color of the sun appear to change?

11. The Sunlight Makes Plants Green.

If a board or plank is laid on the grass for several days, so that the sunlight cannot reach it, the grass will be light yellow, and even white, when the board is first removed. In a few days, however, the grass will regain its usual green color. What caused the change? Potatoes and onions which sprout in the dark have very light green or light yellow stalks and leaves. If these are brought into the sunlight they become green. Although plants may grow in the dim light they need the sunlight in order to grow well and to bear fruit.

Experiment 12.—The Effect of Sunlight upon Growing Plants.

a. Cut a thin slice of cork from a stopper and trim



it into some shape, such as a heart, or a cross, or a clover leaf, and pin it upon a growing leaf which must be left upon the tree. The best way to fasten the piece upon the leaf is to push two pins through it, through the leaf, and into another piece of cork, which is held on the under side of the leaf. Do not touch it for one week. At the end

of a week remove the pieces of cork and report how the leaf appears. Let the leaf remain upon the tree and examine it at the end of another week. What has happened?

b. Try other designs and remove the leaves from the tree when the cork covers are removed. See who can make the best design.

Review Questions, 5.

1. Which way does the Great Dipper move around the North Star, clock-wise or the other way around?

2. Look at the Great Dipper as early as you can see it and as late as you can stay up, and see if you can tell how many degrees it moves in one hour.

3. If the sun rises exactly in the east and sets exactly in the west, through how many degrees does it move? How many hours does it take?

4. At what hour does the sun rise when it rises exactly in the east? Through how many degrees does the sun move in one hour?

5. Why does the sun appear larger at sunrise and sunset than it does at noontime?

6. Why does the sun appear red at sunrise and sunset?

7. Is it ever red at any other time? Why?

8. What makes plants green? How can you show this?

9. When do plants grow best? Why?

10. Did you obtain your answers to these questions from books? What is the best way of obtaining these answers?

12. Other Changes of Color which are Caused by the Sunlight.

If we are out in the sunlight a great deal our skin becomes brown and we say that we are **tanned.** This change of color is due to the sun and it takes place in order to protect the body from the effects of too much sunlight. Some persons do not tan very easily, but become red and often blisters are caused where the skin has been exposed very long to the sunshine. Even persons who do tan easily are sunburned if they try to become tanned in a few days, while if they are not too long in the sunlight at one time, the skin will protect itself by putting a shield between the sun and the tender inner skin. Just as smoked glass shut out so much sunlight that we could look at the bright noonday sun without hurting our eyes, so the tanned skin keeps out the strong sunlight and we can expose it to the sun's glare without harm. If the coloring material is not distributed evenly throughout the skin little patches come which are called **freckles.**

When we speak of the sun as causing plants to be green and the skin to tan, we must remember that the plants and the skin are alive. If the sun shines upon things which are without life it can affect the color which the things have, causing it to become lighter, and in some cases, even making the material white or nearly white. The change in color is called **fading**, while the removal of the color from an object is called **bleaching.**

Experiment 13:—Fading and Bleaching.

a. Obtain several pieces of differently-colored cotton cloth and cut each piece into halves. Keep one of

the halves of each piece in the dark, so that the color will not change. Wet the other halves with water and expose them to the bright sunlight until there is a change in color. The pieces should be kept wet and it may take a few days before there is much change. Make a list of the colors and tell how soon they changed and what each color became.

b. Wet and expose a piece of unbleached white cotton cloth to the bright sunlight. Compare the result with another piece which has not been exposed.

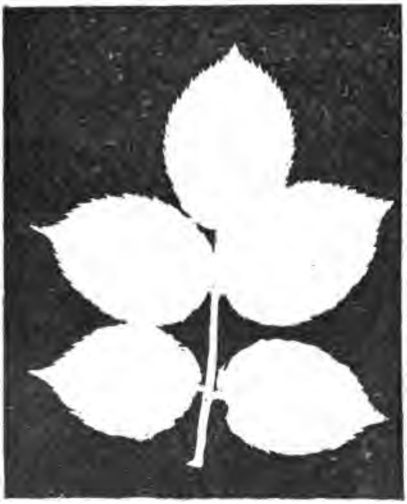
This is the old-fashioned way of bleaching and is the best method, although it is slow. Bleaching may be accomplished much more quickly by the use of chemicals, but the cloth is weakened and wears out more quickly.

The sunlight changes the color of certain chemicals in a strange way. We can make use of this knowledge and cause the sun to print designs for us on paper. The simplest paper for this purpose is called blue-print paper. It may be purchased cheaply or may be made very cheaply. See Section 70.

Experiment 14.—Blue Prints of Leaves and other Articles.

Apparatus: Piece of window glass, leaves, lace, any thin article, blue-print paper at least 4″x5″.

a. Lay a piece of blue-print paper face up upon a



book. Place upon this a leaf, a piece of lace, or any thin article, and cover with the piece of glass. Expose to the bright sunlight until the color of the paper is a bronze. This color must be learned by experience. When you think that the color is right, remove the paper and wash it for five minutes in running water, or move it about in a basin of water. The exposed part of the paper should be a dark blue, while the rest should be a pure white. If the blue color is not dark, it means that you did not leave the paper in the sunlight long enough. If the light part is not white, but is somewhat blue, it is because you exposed the paper too long. You should repeat this experiment at home until you can obtain clear white prints upon a dark blue surface.

Blue-print paper will also be used in Experiments 68 and 75.

Review Questions, 6.

1. If the sun should rise exactly in the south-east, tell exactly where it would set. Why?

2. If the sun rises at six o'clock where do shadows point at that time? Can you devise some method of telling the exact east? Can you do this by means of the sunset?

3. Is the sun ever exactly overhead? If it should be exactly overhead what would the length of shadows be then?

4. What is the best way of measuring the height of the sun?

5. How could you make a yellow figure upon a red apple?

6. What does the sun do to your skin? Why does this happen?

7. What does the sunlight do to color?

13. The Sunlight Good for Plants and Animals.

Although plants cannot move about the same as animals, they do turn their leaves toward the sun and even grow in the direction of the sunlight. Look at the plants which are near the window in the room, and notice how they lean toward the sunlight. This shows that the sunlight is good for plants. If there were no sunlight most of the plants would soon die.

The sunlight is also good for animals and man. If a person stays indoors too much he will become sickly. We should be out in the sunlight as much as possible, and our buildings and houses should have many windows so that the sunlight can enter freely. The sun has a stimulating effect upon the body, and often persons take **sunbaths** to improve their general health. Taking a sunbath usually means sitting in the sunshine, but in hospitals they are given by having the patients lie on cots, being covered only by a sheet.

There is another way in which sunlight helps us and that is by killing disease germs. Much of our sickness is caused by little plants, called **bacteria,** which are so small that they cannot be seen. These plants grow best in dark and damp places and for that reason we should live in dry and sunny houses. If the sunlight which comes in through many windows is too much for our comfort we can shut it out, but if the windows are too few in number there is no way of obtaining enough sunlight. Windows are as cheap as the wall they take the place of, and to have few windows is no economy.

14. Light Travels in Straight Lines.

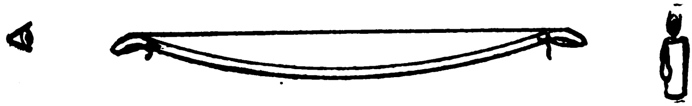
What is meant by a straight line? When we say "As straight as a string," do we mean a tightly pulled string or a loose string? If carpenters wish to mark a straight line on a building they rub some chalk upon a string, stretch it tightly where they desire the line, and then pulling the middle out a little, let it snap back upon the wall. Some of the chalk leaves the string and makes a straight line. Why is the line straight? Try making straight lines with a **chalk-line.**

Now that you know just what is meant by the word "straight" you can see that light travels in straight lines. If there is a candle or a lamp in a room, can you go anywhere in the room so that you cannot see the light? How does the light come to you from the candle or lamp, straight or curved?

Experiment 15.—The Way Light Travels.

Apparatus: Slim stick three or four feet long, string, two pieces of cardboard, candle.

a. Make a bow of the stick by means of the string, having the string come over the ends of the stick. Sight



along the tight string at a candle. Does the light come to your eye in a straight line?

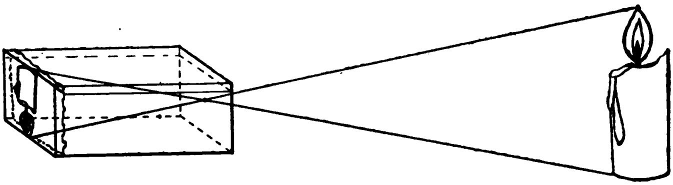
b. Make a hole with your pencil point through the center of one piece of cardboard, and hold it three or four inches from the lighted candle. Hold the other piece of cardboard near the first piece, on the side away from the candle. What do you see? A darkened room is best for this experiment. If you do not see anything distinctly it may be because the hole is either too large or too small. What you see is an **image.** Explain why the image has the position in which you see it? If light started from the top of the candle and passed through the hole, in a straight line, would it strike the top or the bottom of the second piece of cardboard?

Experiment 16.—How to Make and Use a Pin-hole Camera.

Materials: Chalk box, piece of ground glass to fit as cover to chalk box, tinfoil, cardboard box, waxed or greased paper to cover one end of cardboard box.

a. Cut a hole in the center of the bottom of the chalk box about one-quarter of an inch across. Cover this hole with a piece of tinfoil and make a pin-hole in it. Slide the ground glass into the chalk box as a cover, with the ground side out. The camera is finished.

b. Second method.—Break one end out of a cardboard box, paste the cover on, and cover the open end



with waxed paper, or paper with grease on it. Make a hole with a pencil point in the end of the box which is opposite the paper. Both cameras may be used in the same way, but the first one will give better images.

c. Turn the pin-hole end of your camera toward the objects you wish to see in the camera. Bright objects are the best for this purpose. Cover the head and the other end of the box with a cloth, or a jacket, and you will see an image in all its natural colors. Where is the top of the image? Where is the right side of the image? How do you explain this result?

Review Questions, 7.

1. If you look along the surface of a body of water and then look exactly overhead, through how many degrees have you tipped your head?

2. If plants die, will the sun make the leaves green? What besides the sunlight is necessary in order that the plants be green?

3. What is the use of tan upon the skin?

4. What is the harm of using chemicals to bleach cloth?

5. How do plants show that sunlight is good for them?

6. If you were choosing a house in which to live, what would you notice especially?

7. Give two proofs that light travels in straight lines.

8. Why is the image in the pin-hole camera upside down?

15. The Reflection of Light.

Light travels in straight lines until it strikes against something. Then it is turned back, and, although it still travels in straight lines, the direction of the light has been changed. This turning, or bending, of light is called **reflection.** When the object which causes the reflection is smooth and shiny we seem to see the light in the object. If you look at the reflection of any object in a mirror, it seems to be back of the mirror. This is called **regular** reflection, because what we see appears just like the object. The appearance of an object in a mirror is called an **image.** Can you imagine why it is called an image?

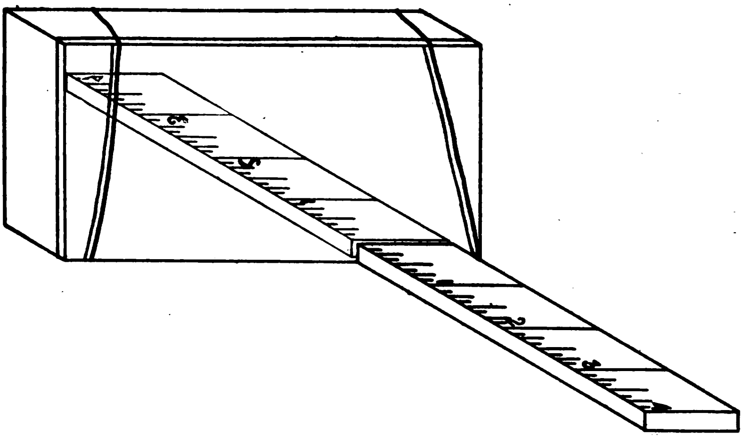
Experiment 17.—Reflection from Mirrors.

Apparatus: Mirror at least 2″x4″, block of wood 2″x2″x4″, two rubber bands, foot rule, pin.

a. Turn the mirror toward the sun but tip it downward so that the reflected light is on the wall about as high as your head. Now turn the mirror about 45 degrees to the right. Through how many degrees does the spot of light move? Repeat, turning the mirror to the left. What result do you obtain? In turning the mirror from the right position to the left position you moved it

through 90 degrees. Through how many degrees did the spot of light move? Make a drawing to show how the light came from the sun and was reflected from the mirror.

b. Fasten the mirror to the block of wood by means of the rubber bands, and place it on a board. Stick a



pin two inches in front of the mirror and place the rule so that its end touches the mirror and the pin comes at the two inch mark. Look in the mirror and tell how far back of the mirror the image of the pin is. Place the pin at different distances and repeat. Having made several trials, and having obtained the same results in each trial, you can now draw your conclusions. How far back of the mirror is the image compared with the distance the object is in front of the mirror?

If the object upon which the light falls is rough some of the light is reflected, but, since the rough surface is made of tiny surfaces which face in all directions, the light is scattered in all directions. In the case of this experiment we cannot see the sun in the object if it is shining upon it, but we see that the object is brighter. We call this scattering of light, **diffused reflection.** All objects which give light are seen by the light which they produce; all other objects are seen by the light which they reflect. Light is diffused by particles of dust and tiny drops of water in the air which are too small to be seen. The light which we receive from the sky and from clouds is due to diffused reflection. Diffused light is best for the eyes.

Experiment 18.—Diffused Reflection of Light.

Apparatus: Two blackboard erasers, glass.

Materials: Little milk, sheet of white paper.

a. Darken the room except for one window through which the sunshine is coming. Notice the particles of dust which are shining by reflected light. Stand across the room and look for the particles in the sunbeam. Can you see them? Why? The sky is bright for the same reason that the sunbeam appears to be bright. If there were no dust in the air you could not see a sunbeam. Knock two blackboard erasers together in the sunbeam and tell what happens. Look at your companions' faces as you do this and see if they become brighter.

b. Put a glass of water in the sunbeam and notice how it appears. Now add a drop or two of milk. What color does the water become? Could you see a glass of water across the room better if there were a few drops

of milk in it? Why? Add some more milk and tell what color the water becomes. When only a little light is reflected what color is reflected? Why is the sky blue? If all the light is reflected what color is it?

c. Notice the amount of light upon the ceiling. Now hold a sheet of white paper in the sunbeam and tell what change there is in the amount of light. The moon shines by light reflected from the sun, so moonlight is only sunlight which has gone to the moon before coming to us.

Review Questions, 8.

1. Face the north. After turning 135° to the right, in what direction are you facing? If you had turned to the left, in what direction would you be facing?

2. If the sun is in the south direction every day in the year, at noon, how can the sun be farther south in winter than in summer?

3. If the sun sets at quarter before seven o'clock, at what time will it rise next day?

4. What is the best manner of finding the line which is half-way between the shadows in Experiment 3?

5. What is the cause of freckles? Why do not all persons become freckled?

6. If you looked at a very large and very bright mirror would you see the mirror? Explain.

7. How do you see other persons? Do they give light?

8. If you are five feet in front of a mirror and then move three feet nearer, how much nearer are you to your image?

9. Why are shades used over lamps and other lights?

10. Why is the sky blue? You have seen the sky when it is nearly white; what might cause a clear black sky?

16. Light from Sources Other Than the Sun.

The sun is by far the best source of light. There is no light so powerful, and none so beneficial to plants and animals. Most animals, except those that prowl at night, go to sleep soon after sunset; but man has long been accustomed to staying awake much later. The need of light was first met by the use of campfires. If a person wished to leave the campfire he would remove a burning stick or fire-brand, and carry it with him. Thus the torch was a natural outgrowth from the campfire. Later, man learned that some kinds of wood, or wood which had been soaked in grease, made better torches than a fire-brand taken from the campfire. Still later, man made lamps in which wicks burned in grease or oil. The flame was uncovered and was smoky and dim. The candle was a much more modern invention and, as you know, is still used. The modern oil lamp, having the flame covered with a chimney was a vast improvement over the ancient oil or grease lamp. The burning of illuminating gas was the next advance in lighting and was soon followed by the electric light.

In all of the methods of producing light, except by electricity, we obtain more heat than light in all cases where light is obtained from burning a material. Even the electric light produces more heat than light.

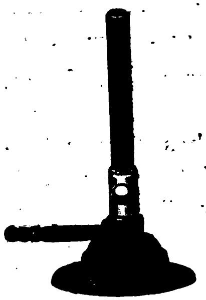
Experiment 19.—Ordinary Sources of Light.

Apparatus: Oil lamp, Bunsen burner, gasoline

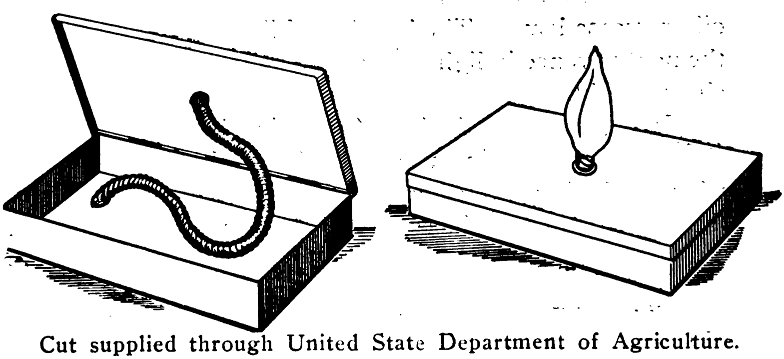
lamp, or alcohol lamp, test tubes, test-tube holder.

Materials: Pieces of wood, candle, iron wire No. 28, soft coal.

a. Darken the room as much as possible. Burn pieces of wood (matches will do) and describe the light which is obtained. Light the candle. Is the light steady? Why? Light the kerosene lamp but do not put on the chimney. Describe the flame and light obtained. Would you like to be in a room for a long time with this kind of a light? Put the chimney on and state what difference you note.



b. If there is gas in the school, light a Bunsen burner and describe the light when the dampers at the bottom are closed. Open the dampers. What is the difference in the light? Hold a piece of No. 28 iron wire, coiled into a spiral, in the flame. Where does the light come from? Light the alcohol lamp. What kind of light does burning alcohol give? Could you read by it. Hold the iron



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spiral in the flame. Could you read by this light? This kind of light is called **secondary,** because it is caused by the heat of the flame, although the flame gives very little light. First the heat comes from the flame, and second the light comes from the wire.

c. Put a few pieces of wood, or soft coal, in a test tube and hold it, by means of the test-tube holder, in the alcohol or gas flame. Tell what happens. See if you can light what is coming out of the tube. It is gas. A large amount of gas is made by heating coal.

While the heat from our sources of light is very acceptable during cold weather, it becomes decidedly unpleasant on the hot nights when we must use lights. For this reason scientists are trying to obtain some source of light which will produce less heat than any we now use.

The whiter the light the less heat is produced compared with the intensity of the light. Thus reddish or yellowish lights produce much more heat than light, while white light, although it produces a large amount of heat, yields more light in proportion. Name some yellow lights and some white lights. Nature supplies a yellowish light which is practically cold. Fireflies and glowworms are examples of this sort of light. Try to catch some glowworms and examine them. Decaying fishbones sometimes give a faint light, but, like the light obtained from fireflies and glowworms, is of no practical

value. This kind of light is called **phosphorescence.** So far, man has not produced any really cold light which is sufficiently strong for practical purposes. The experiment shows one form of cold light which is used to a slight extent on match-boxes, clock faces, and around door bells so that they may be seen in the dark.

Experiment 20.—Cold Light.

Apparatus: A matchbox with the word "matches" made of luminous paint.

a. Place the matchbox so that the direct sunlight will fall upon it for at least ten minutes, and then examine it in a dark room. It may be necessary to remain in the dark room for a few minutes before your eyes will become accustomed to the darkness. What do you see?

b. Keep the matchbox in a perfectly dark place for two or three days and then examine it without removing it from the dark. Can you see anything?

c. Place the matchbox in the sunlight for ten minutes and again examine in a dark room. What do you conclude is the real source of light in the case of luminous paints?

Review Questions, 9.

1. What side of trees has the most moss? Why?
2. How can you locate the south by means of a watch?
3. If the sun rises exactly in the east, what is the time of sunset?
4. Could you tell time by the Great Dipper?

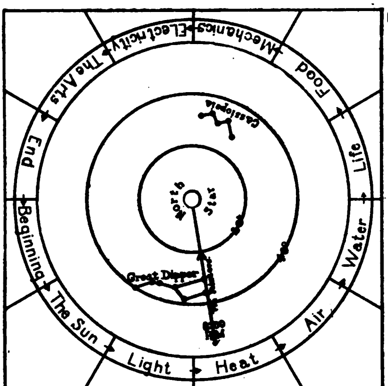
5. What are some of the advantages of sunlight?

6. What are the two kinds of reflection, and what is the chief difference between them?

7. If you move a mirror 10°, how much will a reflected beam of sunlight move?

8. What are some of the sources of light?

9. Why does most light give heat?


Mechanics
Electricity
The Arts
End
Beginning
The Sun
Light
Heat
Air
Water
Life
Food
Cassiopeia
North Star
Great Dipper

THE GUIDE

HEAT.

17. The Heat we Receive from the Sun.

The heat which we receive from the sun is necessary for animal life and for plant life. As you know, it is useless to plant seeds in very cold weather, and animals often die when they do not have a warm place in which to live. (Later we shall learn more about the effect of heat upon plants.)

Just as the amount of light which we receive from the sun varies with the different seasons, so the amount of heat which we also receive from the sun changes from hour to hour and from season to season. When is the warmest part of the day? When is the coolest part? Look back at Section 10 and try to explain why this is so. When is the warmest part of the year? When is the coldest part? Perhaps you may obtain a suggestion from Section 9. The next experiment will show why the heat from the sun varies as it does.

Experiment 21.—*The Varying Heat from the Sun.

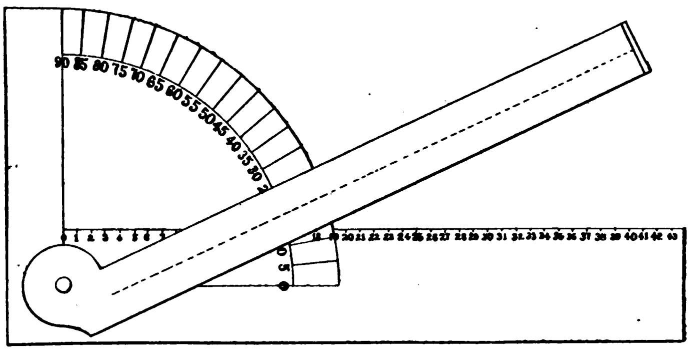
Apparatus: Scissors, protractor.

Materials: Cardboard 12″x8″, paper staple.

a. Make the apparatus as shown in the illustration. The radius of the quarter circle should be five inches. The divisions numbered 1 to 44 should be one-fourth inch, and the movable strip should be one inch wide. One inch of the end of the strip should be bent up and a quar-

* See Section 62 before performing this experiment.

ter inch hole made in the center. The line of divisions represents the surface of a small part of the earth; the movable piece represents a sunbeam one inch wide.



When this "sunbeam" is perpendicular to the "surface of the earth" it covers one inch. How many degrees are needed between two lines to make them perpendicular to each other? If the "sunbeam" is at any other angle it covers more than one inch of the "surface of the earth." Now if you had just enough butter to cover one slice of bread but had to cover two slices with it, how thick would the butter be? Suppose that you were so unfortunate as to be obliged to cover three slices with the same amount of butter, how thick would the butter be? In a manner similar to this the sunshine is spread "thick or thin" upon the surface of the earth, as the height of the sun varies with the time of day and with the changes of season.

b. Place your apparatus in the sunshine early in the morning, or late in the afternoon, in such a manner that the movable arm "sunbeam" may be aimed at the

sun, while the "surface of the earth" is parallel with the real surface of the earth. The best way to do this is to place the arm in such a position that the sun shines through the hole in the bent end and falls lengthwise along the middle of the strip. Read the angle on the protractor. This is the elevation of the sun. Count the number of spaces covered by the "sunbeam." How strong is the sunlight compared with what it would be if it were perpendicular to the "surface of the earth?" Remember your buttered bread!

c. Repeat (b.) at noon. What is the elevation of the sun? How many spaces are covered by the "sunbeam"? How strong is the sunlight compared with what it was early in the day?

d. Take a reading once a week, of the sun at noon and the number of spaces covered by the "sunbeam." Continue this experiment the rest of the year. Keep a record and compare it with the record which you are keeping of Experiment 10

The amount of heat which is taken up by different objects is very different, although all of the objects may be near one another in the sunshine. Shiny objects do not become very warm in the sunshine. What is the effect of shiny objects upon light? They do the same thing to heat and therefore they do not become warm. White objects and those having light colors also are quite cool in the sunshine, but are warmer than the shiny objects because they do not reflect so much heat. Dark colored and rough objects reflect very little heat

and thus become very warm. What color of clothing should be worn in hot weather? Why?

Experiment 22.—The Amount of Heat Received by Different Colors.

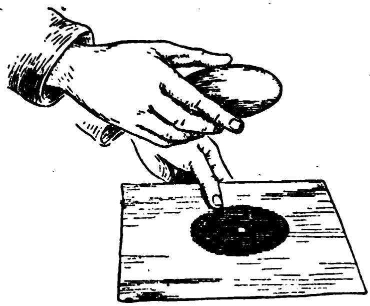
Apparatus: Two spice cans of the same size, kerosene lamp, pieces of paper, white, red, yellow, and black.

a. Polish one spice can and smoke the other in the flame of a kerosene lamp. Fill each with the same amount of water and expose both in the bright sunshine. At the end of twenty minutes dip a finger into each and tell what the difference is between them. See Section 71.

b. While waiting for the water to become warm expose the pieces of paper to the bright sunshine and arrange them in the order of their warmth, putting the hottest one first and the coldest one last.

We have seen that the amount of heat from sunshine varies with the altitude of the sun, because when the sun is low a given amount of sunshine is spread over a much greater surface than when the sun is higher. Do you think that if we could cause more sunshine to fall upon a certain surface it would become warmer? See Experiment 17.

There is another means by which light and heat may be gathered together so that what falls upon a large surface is caused to cover only a very small surface. This is accomplished by the use of a circular shaped piece of glass, thicker at the center than at the edges, called a **lens,** or "burning glass."



Experiment 23.—"The Burning Glass."

Apparatus: A lens at least 3″ in diameter.

Materials: Bits of paper, cloth, wood and leather.

a. Hold the lens flat to the light as it comes from the sun and catch the light, after it has passed through the lens, upon a piece of paper. Move the lens toward or away from the paper until the spot of light is as small as possible. Tell what happens. Why is it best to have the spot of light as small as possible? Repeat, using cloth, wood, and leather in the place of paper. Which do you think would become hot quicker, black or white paper? Try it. Notice the dark ring around the bright spot. Where has the light gone?

Review Questions, 10.

1. What is the difference between fading and bleaching?
2. What is a sunbath? How are they taken?
3. What is diffused light? How can it be produced?
4. Which is hotter, red light or white light?
5. Give some examples of cold light.
6. What part of the day is hottest? Why?
7. What material becomes the hottest in the sunshine?
8. How may we obtain a large amount of the sun's heat in a very small space?

9. Write to pupils in schools four or five hundred miles to the east or west of you, and ask them to tell you the position of the Great Dipper at eight o'clock.

18. Expansion Due to Heat.

Whenever anything is heated it becomes larger. This increase in size is called **expansion.** It is an increase in length, breadth, and thickness. In **liquids,** such as water, we notice the increase in volume. The increase of volume is also evident in the case of **gases,** of which air is an example. In solids, however, it is the increase in length only, which causes us to be watchful.

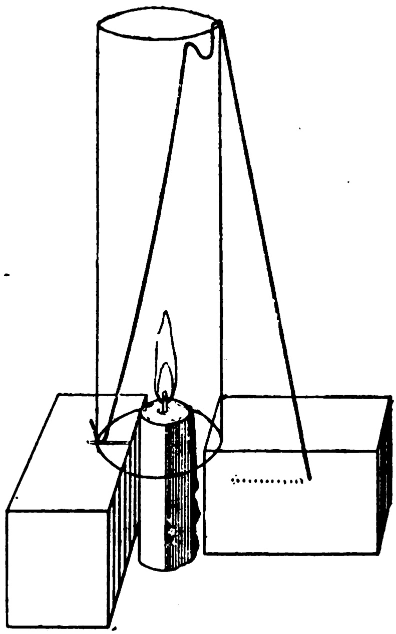
The next time you are near a railroad track look for the spaces between the ends of the rails. Are the spaces large or small? Is the day hot or cold? If these spaces were not left when the rails were laid in cold weather, they would expand in hot weather and having no space in which to expand, would bend sidewise, allowing the car wheels to leave them. If you were laying rails on a very hot day would you put the ends close together, or would you leave a space between them?

A practical use of expansion due to heat is made in putting iron tires upon wheels. The tires are quite hot when they are placed around the wheel and, as they cool off they **contract**; that is, become smaller and thus grip the wheel very tightly. See Section 72.

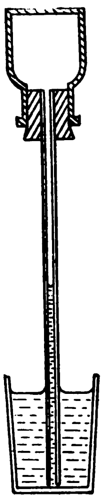
Experiment 24.—Heat Causes Expansion.

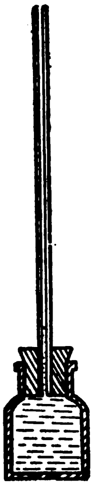
Apparatus: Lamp chimney, candle, two small blocks of wood, iron wire No. 18, rule, 4-ounce bottle, cork to fit bottle, glass tube one foot long, tumbler, alcohol lamp or Bunsen burner.

a. Arrange apparatus as shown. Light the candle and immediately mark the position of the end of the wire. Watch it and tell what happens. What causes the change? Blow out the candle and explain what happens.



b. Bore a hole in the cork stopper so that the glass tube will fit it snugly. Push the tube into the hole so that the end is even with the inner side of the stopper, and insert the stopper tightly into the bottle. Place the other end in a tumbler of water. Warm the bottle with the hands, while watching the end of the tube which is under water. What happens? Why? Now warm the bottle gently with a flame? What occurs? Allow the bottle to cool. What do you see? Why? As the air cooled it contracted thus occupying less room, or space. The surface of the water in the tube merely fits against the air.





c. Fill the bottle with cold water and insert the stopper. The water should run up the tube not more than two inches. Mark the surface of the water with a piece of string tied tightly around the tube. Heat the bottle gently and tell what happens. Explain. Let the water cool and explain what happens.

Some materials expand more than others when they are heated. Thus tin expands twice as much as does steel, while lead and zinc expand still more. Steel expands the least and zinc the most. This difference of expansion leads to results which appear strange until we think about what is occurring. A common example is the loosening of preserve jar covers when the jars are turned upside down and the covers placed in hot water. The metal cover expands more than the glass does and becomes loose.

Experiment 25.—The Result of Unequal Expansion.

Apparatus: Apparatus as shown in cut, consisting

of a bar of brass and a bar of iron fastened together, alcohol or gas lamp, bottle to hold apparatus.

Materials: Ice, salt.

a. Notice that the bars are straight. Heat very hot by holding the bars in the flame. Which way do they bend, with the brass or the iron outside? Which

expands the more, brass or iron? Let the bars cool and see if they are straight, as at first.

b. Put the bars in salt and ice and let them become cool. Which way do they bend? A metal which, when heated, expands faster than another metal, also contracts faster when cooled. The unequal expansion of metals is made use of for practical purposes. The illustration shows a strip of two metals which are joined together their entire length, and then bent into the shape of a shepherd's crook. As the metals become warmer, due to the increased warmth of a room, the metal on the right expands more than the other metal and causes them both to bend to the left. This bending brings together the double metal and a screw which act like an electric push button. Instead of ringing a bell, however, the electricity changes the dampers of the furnace so that the air of the room will not be so warm. When the room cools off, the metals bend the other way and cause the electricity to open the dampers again. The machine is called a **heat regulator** because it **regulates** the amount of heat which a room receives.

Cut supplied by the Jewell Heat Regulator Co.

Review Questions, 11.

1. What are the advantages of a sunny house?

2. How does heat come to us from the sun, in curves or in straight lines? What makes you think so?

3. Why do you cover your head when you look at the image in a pin-hole camera?

4. When you are reading at night should you have the light shining directly into your eyes? How should you light your books?

5. Can you really see a sunbeam? What do you see?

6. What color of clothes should we wear in summer? Why?

7. What is expansion and what causes it?

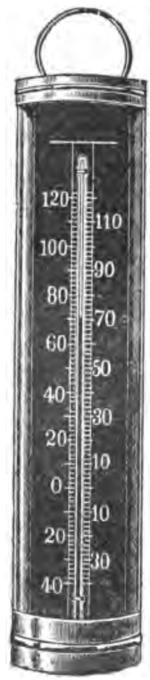
8. Do all things expand the same amount?

19. The Thermometer an Application of Expansion.

It is warm today? How do you judge? If you have been running it may seem warmer to you than to someone who has been sitting quietly. The best way to learn about the warmth is by means of a **thermometer.** This is merely a tube with a large end called a **bulb,** and is much like the bottle and tube which was used in Experiment 24, c. In fact, we can use that apparatus in the place of a thermometer, but the change in the height of the water would be too little to measure easily for ordinary changes of warmth. We saw, however, that as the water became warmer it expanded and ran up the tube. When anything is hot we say that it has a high temperature, and when it is cold we call the temperature low. Thus we can make this statement: When the temper-

ature rose the water rose in the tube, and when the temperature went down the water also went down. Temperature then, is the condition of warmth, high temperature being very warm and low temperature very cold.

The usual thermometer is a very thin tube closed at one end and with a bulb at the other end. This bulb may contain mercury, sometimes called quicksilver, or it may contain colored alcohol. It is the mercury or alcohol in the bulb which expands and pushes a tiny thread of liquid up the tube. The thermometer is marked either on the glass or on the back, into divisions called **degrees,** and these degrees are numbered from zero up and down. There are two kinds of markings on thermometers. The thermometer which is used ordinarily is called by the inventor's name, **Fahrenheit,** and has the temperature of freezing water marked 32 degrees, and the temperature of boiling water marked 212 degrees. The illustration shows a Fahrenheit thermometer. The other thermometer is used by scientists everywhere, and in many foreign countries by everyone. This is called the **Centigrade** thermometer and has the freezing temperature of water marked 0 degrees and the boiling temperature of water marked 100 degrees. Of course the temperature of freezing water is really just the same no matter what it is called, just as you are the same person whether you are called by



your real name or your nickname; that is, 32 degrees Fahrenheit and 0 degrees Centigrade are the same temperature. The temperature of boiling water is also the same although it is called 212 degrees Fahrenheit and 100 degrees Centigrade. If you do not state whether the temperature is according to the Fahrenheit thermometer or the Centigrade thermometer, it is understood to be the Fahrenheit. Degrees are marked the same as the degrees of a circle, that is, in the place of writing 60 degrees Fahrenheit we may put 60°F.

Experiment 26.—How to Read a Thermometer.

Apparatus: Cheap thermometer.

a. Count the number of divisions between the figures 40 and 50. How many **spaces** are there? What is the difference between 40 and 50? Then how many degrees does each space mark? All thermometers are not marked the same and you should find out every time you use a thermometer just how many degrees are covered by each space.

b. Obtain the temperature of the room. To do this the thermometer should come to rest, that is, there should be no difference between two readings taken two or three minutes apart. The temperature of a room should be 65 to 68 degrees Fahrenheit at the same height as the heads of those sitting. If the temperature outdoors is more than 68 degrees the temperature indoors may be uncomfortably high, but we should try to keep the temperature at 68 degrees.

c. Take the outdoor temperature in the morning just before school begins, at noon, and at the close of

school. Keep a record of the temperature and you can tell the hot days and the cold days, without trusting to your memory. A record is to be trusted. See Section 69.

Another practical application of the unequal expansion of metals is the dial thermometer. You have all seen thermometers which have a hand moving over what appears very much like the face of a clock. In the place of the hours, however, the face is marked into divisions which are numbered usually from zero to a hundred or more. The word "Fahrenheit" generally is printed upon the face of the instrument. The movement of the hand is caused by the winding up, or the unwinding, of a spiral, due to the unequal expansion of the two metals of which it is composed. The illustration shows the spiral but does not show the two metals. Both metals are quite thin and are fastened together their entire length just as we learned the heat regulator was made.

We should not depend upon our feelings in regard to temperature. If we have been exercising we are warm

Cut supplied by the Standard Thermometer Co.

and may endanger our health by remaining in a room which seems comfortable, when really it is too cold. The thermometer is the only true guide to be followed if we wish to know the real temperature. Of course, if we are exercising, the temperature may be much below 68 degrees and do us no harm. The temperature of 68 degrees is proper for persons who are sitting still, or moving about only a little. Is your room at the right temperature?

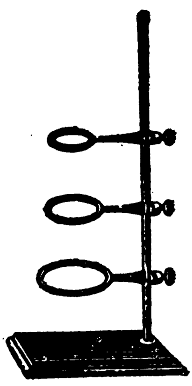
The following experiment will show you how little it is possible to trust our feelings or sensations.

Experiment 27.—Hot or Cold?

Apparatus: Three cups or other similar dishes, sauce pan, alcohol or gas lamp, ring stand, wire gauze.

Materials: Ice.

a. Fill one cup with water which is as hot as you can bear putting your hand into; fill the second cup with water at the temperature of the room; the third cup should be filled with ice cold water. Place the fingers of one hand in the hot water and those of the other hand in the very cold water and let them remain for one full minute. Then place the fingers of both hands in the cup containing the water at the temperature of the room. How do the fingers feel? Is the last water hot or cold? Can you trust your sensations?



Review Questions, 12.

1. If the sun rises at seven o'clock, at what time will it set?

2. On which side of a street is it better to live, the north side or the south side? Before answering think where the sun is at noon and the direction from which the sunshine comes.

3. What is one thing we can do in order to keep well?

4. How may we obtain light from a flame which gives a large amount of heat but gives no light of itself?

5. If a person could be dressed in very shiny clothing, just like a mirror, would he be warm or cold in the sunshine? Explain.

6. What use is made of the expansion of metals?

7. What use is made of the expansion of liquids?

8. How do you read a thermometer?

9. If the temperature in the morning is 48°F. and at noon it is 65°F., what has been the change in temperature?

10. Why should we not depend upon our feelings concerning the temperature of a room?

20. Heat Produces Light.

In Section 16 we learned that heat is one of the sources of light and that it is impossible, as far as we know at the present time, to produce cold light which is strong enough for ordinary use. The light which we obtain from heat, however, is not always the same, for we have a dull red light, a yellow light and a dazzling white light. What causes the difference? Did you ever see a blacksmith working at his anvil? Sometimes the iron is red-hot when he removes it from the forge, and sometimes it is white-hot. Now you know the difference, and if you are nearby you can feel the difference.

We have learned that water boils at 212° Fahrenheit, and we have always thought of "boiling hot" as being very hot. Of course we have known that the fire is much hotter but we have never thought much about it. Ice water (32°F.) is changed to boiling water (212°F.) by an increase of 180°, yet the lowest temperature at which there is a dull red light is about 950° Fahrenheit. The temperature of bright red light is much higher, yellow light is caused by a still higher temperature, while dazzling white light is caused by the extremely high temperature of 2200°F. The electric light which we have in our houses is a good example of light from heat.

21. Heat from Friction.

When two objects are rubbed together we say there is friction between the objects. This friction makes it hard for the objects to move past each other and it requires more strength where there is much friction than where the friction is less. Oil has the power to reduce the friction between two objects and for that reason we oil the bearings of machinery, also the curves of railroad tracks, or we grease the places where we want one part to slip easily over another part. Another name for oiling is **lubricating.**

Try rubbing your hands together, pressing them firmly against each other and moving them rapidly. How do they feel? Why do persons rub their hands together in cold weather? Rub a coin on your coat sleeve or on the carpet and tell what happens. Feel of a gimlet after boring a hole, and explain the results. Sometimes the bearings of railroad car wheels become so hot, even if

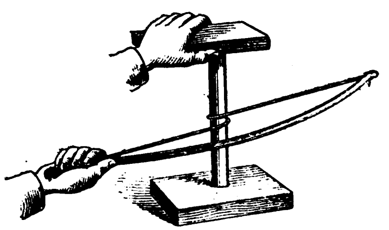
they are well lubricated, that they set the oil on fire, and it is said there is a "hot box."

The old way of making fire depended upon friction. So great heat can be produced by rapidly rubbing two sticks together that they may be caused to glow, and even burst into flame. Indians used this method for making fire but it is hard to do, and requires skill and patience. There is an easier way to accomplish the same result, which we will now try.

Experiment 28.—Primitive Fire-making.

Materials: Two blocks of wood 2″x4″x6″, circular wooden rod 7″long and pointed at both ends, a bow and string, similar to the one used in Experiment 15, lubricating oil or grease.

a. Bore a hole part way through the blocks at their center points, and arrange the apparatus as shown in the illustration. Lubricate the hole in the top block but put nothing in the hole in the lower block. Why is this done? Bear down hard on the top block and move the bow backward and forward very rapidly. You may not



be able to make the lower block burn but you should be able to make it smoke. Does the hole in the upper block become equally hot? Why? This apparatus is called a fire drill; and this method of obtaining fire also was used in olden times.

Another method of making fire was by means of the flint and steel. Flint is a very hard stone and when it is

struck against iron or steel it removes little pieces, and the friction is so great that they become almost white hot. These tiny particles used to be caught upon shredded linen, called **tinder,** which caught fire and burned. As soon as the fire was obtained the tinder was covered up and kept for next time.

Flint was also used for discharging guns. The hammer of the gun carried a piece of flint, and as it fell, it touched a piece of steel sending a shower of sparks down into the powder. These guns were called flint-locks.

Experiment 29.—The Flint and Steel Gaslighter.

Apparatus: A friction gaslighter.

Materials: Alcohol, piece of cloth.

a. Examine the lighter, noticing the steel file and

Cut supplied by the Safety Gas Lighter Co.

the material which rubs against it. This is not flint, but the action of the lighter is very much like the old flint and steel.

b. Make sparks with the lighter. To do so, quickly rub the parts together. Feel of the sparks. Are they hot? Make the sparks in illuminating gas. Does the gas light? If there is no gas try lighting a piece of cloth which is very wet with alcohol. Do gas and alcohol have to be very warm in order to begin to burn?

The modern way of obtaining fire is by means of matches. How do you light a match? What causes the match to light? So the modern way is much like the ancient way, after all. The only difference is that the materials on the head of the match begin to burn at a very low temperature, just as gas and alcohol were set on fire by sparks which were not noticeably hot. As soon as the match begins to burn its temperature rises to more than 1000°F.

Since matches are so easily set on fire, or **ignited,** as it is called, they should be kept where there can be no friction. It is not safe to keep them in the cardboard box in which they are sold, for sometimes mice gnaw through these boxes and ignite the matches by biting them. The best way in which to keep matches is in a tin pail, or box, having a tightly fitting cover. Not only is that the safest way but the covered matches will also be kept dry and good.

Review Questions, 13.

1. What is the color of the sun at sunrise and sunset? Why is it this color?
2. Which is hotter, red-hot or white-hot?
3. Why does the sun appear red when you look at it through a piece of smoked glass?
4. In what direction do plants grow if they are placed near a window? Why?
5. What is a straight line? How can you make a straight line?
6. Why do we receive more heat from the sun in summer than in winter?
7. What are the three sources of heat which we have studied?
8. What would be the result if you did not lubricate the hole in the upper block in Experiment 28?
9. What are the sparks when flint and steel are struck together?
10. What is the difference between the modern way of making fire and the olden way?

22. Heat from Combustion.

By far the greatest amount of the heat which we enjoy comes from the sun. We have seen, however, that as winter draws near we receive less and less heat from the sun, so that it becomes necessary for us to obtain heat from some other source. Our usual source of heat is from the burning of something. **Combustion** is another name for burning.

There are two kinds of combustion, **complete** and

incomplete. By complete combustion is meant that all of the material has been burned and none wasted. This can be accomplished by giving the fire a proper amount of air. Did you ever see heavy, black smoke coming out a chimney? That smoke was part of the material which should have been burned in the fire, and it meant a loss to the one who was running the fire. The smoke showed that there was incomplete combustion. If the combustion had been complete there would have been no visible smoke.

There are other reasons, besides economy, why fires should not be allowed to send off vast amounts of smoke. The particles of smoke, called soot, slowly settle and spoil the appearance of buildings, soil our linen, and affect our health. It is very bad for us to breathe in smoke and soot. In many cities it is against the law to allow chimneys to smoke to any unnecessary amount.

Experiment 30.—Complete and Incomplete Combustion.

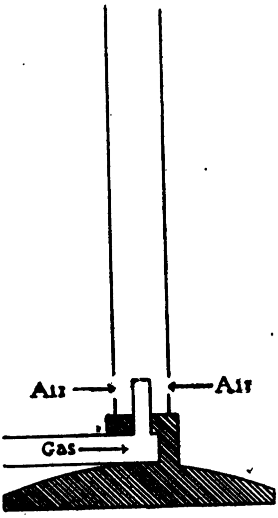
Apparatus: Alcohol lamp filled with alcohol, alcohol lamp filled with turpentine, Bunsen burner.

Materials: Piece of broken chinaware, piece of iron wire No. 28.

a. Light the alcohol lamp. Is there any smoke? Is the flame hot? Hold a piece of fine iron wire in the flame and notice how hot it becomes. Hold a piece of chinaware in the flame. Does anything collect upon it?

b. Light the turpentine lamp. Is there any smoke?

Is the flame as hot as the flame of the alcohol? Why? Which combustion is best?



c. Hold a piece of chinaware in the flame of the turpentine lamp. What collects upon it? What is its color?

d. Hold the piece of chinaware, with its coating, in the flame of the alcohol lamp for several minutes. What does this prove about the wastefulness of smoky combustion?

e. Light the Bunsen burner and note the difference in the flame when the air vents are closed and when they are open. When is combustion more nearly perfect?

23. Combustibles and Fuels.

Anything which burns is a **combustible.** **Fuels** are only those combustibles which we ordinarily burn to produce heat. You are familiar with the common fuels which are coal, coke, wood, charcoal, oil and gas. What do you notice when you burn them? Do they all burn with a flame?

In any combustion it is necessary to have air. In our stoves the amount of air is regulated by dampers. Do you open or close the dampers when you want a hot fire? If there is not enough air the fire will smoke, and finally go out. What causes incomplete combustion?

There is always a waste in the burning of fuels, even when the combustion is complete, for all fuels, except oil and gas, contain substances which do not burn. These substances produce the ashes which we always find under our fires. These ashes often contain particles of fuel which would have burned if the fire had been hotter, so it is seen that there are two losses from incomplete combustion. What are they?

All combustibles, except some oils and some gases, come directly from plants or animals. The following experiment will show the difference between the two kinds of combustion.

Experiment 31.—The Combustion of Different Materials.

Apparatus: Alcohol lamp or Bunsen burner.

Materials: Wood, charcoal, coal, coke, paper, straw, feathers, piece of wool, piece of silk, piece of cotton, piece of linen, whalebone, piece of leather.

a. Hold a piece of each material in the flame and note how it burns. Arrange all of those materials which burn easily in one list and those that burn slowly in another list. Which ones come from animals and which from plants? Which is the safest clothing to wear when near flames, cotton or woolen?

Goods may be prepared so that they will not burn readily. This is called **fireproofing.** See Section 73.

24. Flames.

In our experiments with combustibles we found that, while some of them burned with a flame, others only glowed. The difference is caused by a gas, as only gases burn with a flame. But, you will say, you saw wood burn with a flame, and wood is not a gas. That is true, but when the wood is heated so that it ignites, part of it is changed into a gas and it is the burning of this gas which causes the flame. It is just the same with a candle. The wax, when it is heated, changes into a gas and the burning gas causes the flame. Whenever you see a flame you may be sure that a gas is burning.

There are two kinds of flames, those which give a large amount of light and those which give only a very little light. Those flames which give light are called **luminous.** Can you name some luminous flames? Name one flame which is not luminous. How can you obtain light from a flame which is not luminous? Luminous flames show that the combustion is not complete, the light being due to little particles which are not hot enough to burn. A flame which can hardly be seen is the result of very nearly complete combustion, and these flames are much hotter than the luminous flames.

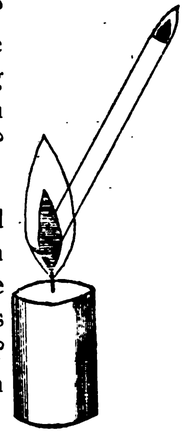
Experiment 32.—The Cause of Flames.

Apparatus: Test tube, test-tube holder, alcohol lamp, piece of glass tubing ¼″ thick, 4″ long.

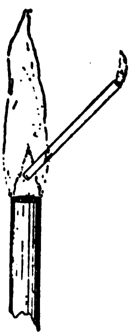
Materials: Bits of wood, candle.

a. Put some bits of wood in a test tube and heat them in the flame of an alcohol lamp. What do you see

collecting on the inside of the test tube? Continue to heat the wood until smoke comes out of the open end. Try lighting this with a match. How does it burn, with a flame or a glow? What must it be? Where did it come from?



b. Continue to heat the bits of wood until the smoke ceases to come off, then remove from the flame. After the tube has cooled a little pour out what remains from the wood. What does it look like? How does it burn? Why does it burn this way?



c. Light a candle, let it burn for a short time, and then blow it out. Have a burning match all ready to hold over the candle. It should ignite. What burns?

d. Light a candle and hold a glass tube in the flame as shown in the illustration. A gas will pass up the tube and may be ignited at the top. Where does the gas come from?

e. If there is gas, try the experiment as shown in the illustration.

Review Questions, 14.

1. What is our guide from which we may learn direction in the open country? How can you find the guide?

2. What direction is 45° to the east of north? What direction is S. 45°W?.

3. Can you see a light in the dark. Can you see a person in the dark? Explain.

4. What kind of light is best for the eyes?

5. What are the sources of heat?

6. When you see smoke coming from a chimney in large quantities what do you know about the fire which causes it?

7. What is the difference between combustibles and fuels?

8. Why do some things burn with a flame while others only glow when they are burning?

9. What are the best combustibles, those from plants or those from animals?

10. What makes a flame invisible?

25. First Aid to the Burned.

If the clothing is on fire the flames may be slapped out, unless a large amount of the clothing is burning. In this case the person should roll, or be rolled, upon the floor. This crushes out the flames. Where possible the person should be wrapped in any heavy material, such as a mat or a rug, or even a coat. The wrapping should be very tight. The person should not be allowed to stand, as the flames will rush upward, setting more of the clothing on fire, and perhaps causing the person to breathe the flame, which is very dangerous. Under no circumstance should the person be allowed to run about. If persons would act quickly, harmful and even many a dangerous burning accident could be avoided. Be quick!

Experiment 33.—Drill for Extinguishing Burning Clothing.

Apparatus: Children.

Materials: Rug or coat.

a. Let one child be supposed to have burning clothing and let two or three other children slap out the imaginary flames, and wrap the burning child in a rug or coat, and roll him upon the floor.

The pupils who do this should be those who are best fitted to illustrate the method for the class. As other pupils improve they should be allowed to show the class this drill, perhaps at the end of each month.

The treatment of burns which are not severe is very simple. Just moisten the burnt part with warm or cold water and put on all the baking soda which will stick. If the burn is quite bad, but has not blistered, the baking soda may be bandaged on the burn with clean cloth which has been torn into strips three-fourth of an inch wide.

If the burns are serious the water blisters should be pricked with a needle, which has been heated ret-hot and used as soon as cool, to allow the water to run out, and then apply a mixture of equal parts limewater and olive oil. Cover the burn with absorbent cotton which has been soaked in the same mixture, and bandage snugly, but not tightly. If the burns are very serious it is best to call a physician.

Limewater may be prepared by putting one ounce of fresh unslaked lime into a pint of cold water, shaking until the lime breaks up, and allowing to settle. The clear liquid should be poured off the top and kept in well-stoppered bottles. A bottle containing equal parts of

lime-water and olive oil should be kept in every kitchen. If limewater is not at hand, use baking soda and olive oil.

Any of the following materials may be used for burns: baking soda, olive oil, limewater, white lead and linseed oil, powdered chalk, cornstarch, laundry starch, flour of any kind, mucilage or dissolved gelatine covered with any of the powders mentioned above. Since quickness means much to the patient, ease in obtaining the remedy should have first consideration.

There is another danger which is connected with burns because the skin is usually destroyed. This gives the bacteria a chance to enter and produce trouble for us. To overcome these little plants we must bathe the affected parts with some material which is an **antiseptic,** that is, something which is against the poisoning. We should do this whenever we break our skin by any means. There are many antiseptic washes to be obtained in drug stores and the proper kind can always be obtained.

Heat is harmful to bacteria if the temperature is 212° F. Where articles are known to contain bacteria they may be killed by keeping them at the boiling point of water for twenty minutes, or a shorter time at a higher temperature.

26. Conduction of Heat.

When we use a stove-poker for a few minutes, the part which we are holding becomes uncomfortably hot. We call this travelling of heat along an object, **conduction.** If the heat reaches the cold end quickly, we say that the material is a good **conductor.**

If we put a wooden handle on our poker, we may

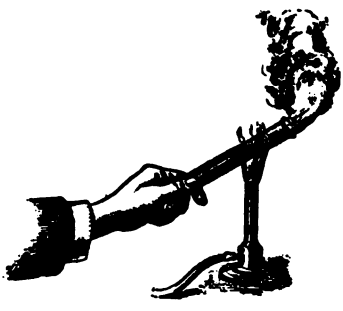
poke as long as we wish and our hands will not be burned. That is because wood is a poor conductor. Most metals are good conductors of heat, although some metals do not conduct heat as well as others. Water is a poor conductor of heat.

Experiment 34.—Good and Poor Conductors of Heat.

Apparatus: Alcohol or gas lamp, pieces of copper and iron wires No. 12, 6″long, test tube.

a. Hold the end of the copper wire in one hand and the end of the iron wire in the other hand, and put the free ends into the flame of a burner. Which one became warm first? Which is the better conductor? Hold the poor conductor in the flame and notice that it takes a long time to become hot at the hand.

b. Fill the test tube nearly full of water and place as shown in the flame of a burner, so that the top of the water is heated. Do not let the flame touch the glass where there is no water, as it will break. When the water boils at the top how it the bottom? Is water a good or a poor conductor of heat? If you wanted to heat water where would you heat it, at the bottom or top? How does the ocean become heated, at the top or the bottom?



If a substance is a good conductor of heat and it is colder than our bodies, it will take heat away from us if we touch it, and we will say that the body is cold. Yet there may be another substance which is just as cold as the first one, but is a poor conductor of heat, and this one will not conduct the heat away from us, and we may say that it is warm. Thus we find that standing with bare feet upon a rug is pleasanter than standing upon the bare floor, or upon an oilcloth. The rug is not a conductor of heat. It is called a non-conductor. Therefore our feet remain warm. The oilcloth, or the bare floor, is a much better conductor of heat and takes it away from our feet and they feel cold. Linen, cotton, and silk feel cold because they are good conductors, while woolen goods and furs feel warm because they are poor conductors of heat. Poor conductors make the warmest clothing.

If the substance is warmer than we are, and is a good conductor, it feels warm because it readily gives its heat to us. A non-conductor does not seem as warm, although it may be warmer, because it does not conduct the heat to us. Here again we must not trust our sensations but must depend upon a thermometer, if we wish to learn the real temperature of the substance.

It is not a good plan to stand upon, or sit upon, materials which are good conductors, when they are colder than we are, for they take our heat away and make us cold. Stones are good conductors and many a chill has been caused by sitting upon stone walls.

If heat is not desired it may be kept out by the use of non-conductors. For this reason milk cans are wrapped in jackets to keep out the heat of the sun on hot days.

Review Questions, 15.

1. What makes the sun appear red and large at sunrise and sunset? Does the sun really change its color and size?

2. What causes the sky to be light blue on some days and dark blue on other days?

3. When you pour hot water into a glass dish the inside expands before the heat reaches the outside. What happens? Is glass a good conductor of heat? Do you think thin glass would break?

4. What is friction? How can you make friction much less than it would be if you did nothing?

5. Why do we build a fire by first putting in paper, then little pieces of wood, and finally large pieces of wood, or perhaps coal?

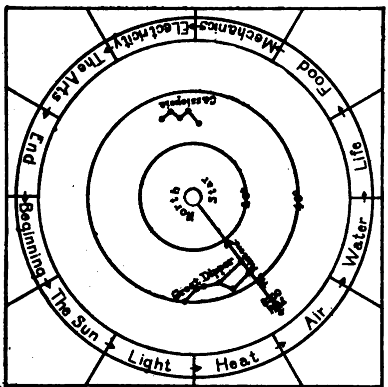
6. What must be done if the clothing is on fire?

7. What is the most common remedy for burns?

8. Why do linen sheets feel cold when we first get into bed?

9. How does the teakettle become warm when on top of the stove?

10. Why do firemen wear woolen shirts? Give two reasons.


Mechanics
Electricity
The Arts
End
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THE GUIDE

AIR.

27. Air a Necessity of Life.

There can be no life of any sort without air. Animals breathe it and plants need it, in order to live. There is air even in water and fishes could not live without this air. We live in an ocean of air which surrounds the whole earth and this ocean is called the **atmosphere.** The meaning of the word "atmosphere" is breath-sphere. Do you think that the atmosphere is well named?

Experiment 35.—Holding the Breath and Deep Breathing.

a. See how many seconds you can hold your breath. You should be able to hold it one minute, with practice.

b. Stand erect with the chest up, without having any of your muscles hard and take just as long a breath as you can, breathing through the nose. When you think that you cannot draw in, or **inhale**, any more air, contract all the muscles of the body, and hold the breath for a few seconds. Slowly let the air come out. Letting the air out is called **exhaling.** Repeat several times and then see how long you can hold your breath. Always take this exercise before holding your breath. Why can you hold it longer than you did at first?

Experiment 36.—*The Effect of Depriving a Plant of Air.

* Adapted from Farmers' Bulletin 408, U. S. Dept. of Agriculture.

Apparatus: Two glasses or bottles, burner, stand, dish for heating.

Materials: Geranium cuttings, olive oil, cardboard.

a. Heat the water slowly. What comes out of the water long before it boils? Boil the water for two or three minutes and allow it to cool.

b. Fill one of the glasses two-thirds full of water which has not been boiled, and fill the other glass two-third full of the boiled water, after it has become cold. Prepare two cardboard covers, as shown in the illustration, and put a geranium cutting in each. Pour olive oil on the surface of the boiled water to a depth of a quarter of an inch, being careful not to get the oil upon the cut end of the geranium slip. Watch the cuttings for a week or ten days and note the difference between the growth of roots upon the two cuttings. Do plants need air in order that their roots may grow?

28. Air in the Soil and in Water.

If we take a handful of soil and examine it we will notice that it is made up of many fine particles of irregular shape and size, which do not fit tightly together. Thus there are left a large number of tiny holes between the little particles, which all added make a large space. These spaces are all filled with air.

When the sun is shining upon the soil it becomes warm and the air in it expands, and some of it comes out of the soil. As the ground cools off at night, the air within

the soil contracts again and more air enters to take the place left by the contraction. Since plant roots need air, can you see the advantage of cool nights during the summer?

Water also contains air, as was learned from the last experiment. In the next experiment we will see just how much air is held in water when it is cold.

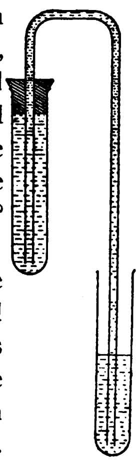
Experiment 37.—To Show the Presence of Air in Soil and Water.

Apparatus: Tin can, glass, two test tubes, one-hole stopper, glass tube two feet long, burner.

Materials: Soil, water.

a. Fill the tin can nearly full of dry soil, loosely packed, and quickly pour a glassful of water upon it. What do you notice? What can you say about the presence of air in soil?

b. Throw away the wet soil and fill again with loosely packed, dry soil. Fill the glass even full of water and pour it slowly upon the soil, not allowing the top of the soil to be covered with water at any time. Continue to add water until the soil will take no more and the water surface comes up to the surface of the soil. How much water have you added? How much air was there in the soil?



c. Arrange the apparatus as shown in the illustration. To bend glass tubing it should be held in the flame of an ordinary gas burner, or an alcohol lamp, or in the flame produced by an attachment for the Bunsen burner, as shown in the illustration, called a

wing top burner. At least two inches of the tube should be heated, and it should be turned slowly so that all sides may receive the same amount of heat. When the glass has become soft, it should be removed from the flame and quickly bent at right angles and held in this position until it has hardened. If the bend is not well rounded it shows that the glass was not evenly heated. The second bend is to be made in the same way.

Fill the test tube full of cold water and after properly arranging the apparatus, gently heat it. The outlet tube should dip into a little water. As the water is heated it expands and passes over into the other test tube. Do you see any air collecting in the heated tube? Where does it come from? If the water is heated too much it will begin to boil and may force most of itself over into the other tube. It is not necessary to heat it until it boils. Allow the water to cool and notice what part of the tube is occupied by air. This is the air which fishes use, and they could not live in water which had been boiled and then cooled.

Review Questions, 16.

1. Which kind of soil will become the warmer in the sunshine, dark colored or light colored? Which is best for early planting?

2. When is the sunshine warmer, when the sun appears red or when it appears white?

3. How many degrees away from the direction of

a shadow is the direction of the light? How do you define these two directions?

4. How can you tell the time of sunrise if you know the time of sunset?

5. What is the proper temperature for the schoolroom and the home?

6. Why does the ground become warm faster than a pond?

7. Which will burn us the more, a piece of wood or a piece of copper, if both are at the same temperature? Explain.

8. Where do we live in our ocean of air, at the bottom or the top? Could we live anywhere else than where we do?

9. Would it do any harm to water plants so much that the ground would be covered with water?

10. What collects on the inside of a glass of cold water if left in a warm room?

29. The Composition of the Atmosphere.

Some mornings when you come to school it is foggy and you think how damp the air is. Even if it is not foggy you have often noticed that the air is damp and you have heard persons say, "Clothes will not dry today." On other days, however, it has been brisk and bracing and the air has been called dry. Though the air has seemed dry it still contained water in an invisible form. It is from the invisible form of water that dew, fog, and clouds are formed.

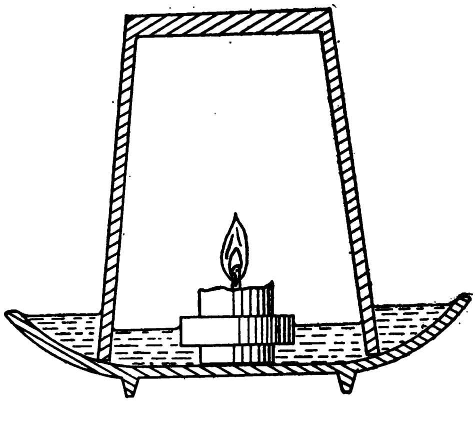
The amount of water in the air varies from day to day and even from hour to hour. The air near large bodies of water usually contains more moisture than

does the air in other places. Why? If you leave a glass of cold water in a warm room, what collects on the outside? There is another part of the atmosphere called **carbon dioxide,** which also varies according to the locality. In the open country there is very little of this gas, but in cities, and in rooms where there are a large number of persons, it may increase so as to harm us, for it is not a good gas to breathe.

Although the amount of water and carbon dioxide in the atmosphere varies greatly, the largest portion of the air is composed of two gases which do not vary. About one-fifth of the air is **oxygen,** and about four-fifths is **nitrogen.** These gases are so important that we will study them one at a time. Thus you see that the air which you thought was just one thing is really composed chiefly of four substances: nitrogen, oxygen, carbon dioxide, and water. Besides these, there are argon, dust, and bacteria.

Experiment 38.—The Amount of Oxygen in the Air.

Apparatus: Saucer, glass, candle, flat cork stopper.



a. Cut the candle so that it is not more than one inch long and make a "life preserver" for it from the stopper. To do this, cut a round hole in the stopper, in which the candle will fit tightly. The cork

need be only one-fourth of an inch thick, but it should be placed near the wick end of the candle. Fill the saucer with water, place the candle upon the water, light it, and cover with the glass. Tell what happens.

b. How high did the water rise? The candle has used all of the oxygen and left the nitrogen. How much of the air is nitrogen and how much is oxygen, according to your experiment? Why did not the candle go out at once? Why did not the water begin to rise when the candle was covered? Before answering this question you must think of the effect of heat upon a gas. See Experiment 24. Why did the water continue to rise after the candle went out?

Note:—The same experiment may be repeated with a large bottle, having straight sides, and a cake pan, or bread pan, to see if the same results will be repeated.

The following experiment is for the teacher:

Experiment 39.—The Amount of Carbon Dioxide in the Air.

Apparatus: A twenty-ounce glass-stoppered bottle, glass measure graduated in cubic centimeters, medicine dropper graduated to hold one-third of a cubic centimeter.

Materials: Limewater solution (pure water left in contact with slaked lime until the water will not take up any more lime. Dilute the clear decanted liquid with 99 times its own volume), phenolphthalein solution (dissolve one part of phenolphthalein in 500 times its own weight of 50 per cent alcohol.)

a. Fill bottle with pure water, and empty it in the place where the air is to be tested. This will insure the bottle being filled entirely with the air of the room. Add 10 c. c. of limewater solution and one-third c. c. of phenolphthalein solution, stopper, and shake. If the red color disappears in three minutes or less, the air is unfit to breathe.

30. Oxygen and its Uses.

We have learned that air is necessary for life of any kind and that it is composed of nitrogen, oxygen, carbon dioxide and water. We have also learned that it is the oxygen which caused the candle to burn since it stopped burning when all the oxygen had been used. Therefore we call oxygen the **supporter** of combustion. Just as the candle needs oxygen in order to burn, so we need oxygen in order to live. It it only the oxygen of the air which the body uses; the nitrogen is exhaled unchanged. If there are many persons in a close room most of the oxygen will soon be used and the air will become unfit for breathing. Headaches and drowziness are more often produced by bad air than by hard lessons. Yawning is caused by a desire to obtain more oxygen.

Since it is the oxygen of the air which supports combustion and air is composed of only one-fifth oxygen, we might suspect that combustibles would burn much more vigorously in oxygen than air. Let us see if this is true.

Experiment 40.—To Prepare and Use Oxygen.

Apparatus: Test tube, test-tube holder, burner.

Materials: Potassium chlorate (powdered), manganese dioxide, splinters of wood.

a. Mix equal parts of potassium chlorate and manganese dioxide on a piece of paper, and pour into a test tube. Hold the test tube in the flame of the burner, by means of the test-tube holder, until it becomes very hot. Then light a splinter of wood, let burn for a while, blow out the flame, and insert the glowing end into the tube, continuing to heat the tube. What happens? There is oxygen coming from the mixture in the tube. Does wood burn better in oxygen than in air? Is oxygen invisible or visible? Colored or colorless?

Review Question, 17.

1. Why does the skin become tanned?
2. If you run toward your image in a mirror going ten feet a second, how fast will you approach your image?
3. How should the lights of a house be arranged to give the best light for the eyes?
4. Why are woolen underclothes better protection from cold than cotton garments?
5. Should the thermometer hang near the floor, on the level of your head, or near the ceiling of a room to be of use to us?
6. How can you show that there is air in water?
7. Give all the reasons which make you think that there is water in the air.
8. How can you show that about four-fifths of the air is nitrogen?
9. Why does pure oxygen support combustion better than air?
10. What is one cause of headaches?

31. Nitrogen and its Uses.

As we have learned, about four-fifth of the air is nitrogen. We saw that it was oxygen which supported combustion and that pure oxygen supported combustion much more vigorously than air, because air is only one-fifth oxygen. What do you think the effect would be upon fires if all of the air were oxygen? One of the uses of nitrogen, then, is to lessen the effect of oxygen. Where the amount of one substance is reduced by the addition of another we say that the first substance is **diluted,** and call the process **dilution.** Nitrogen dilutes the oxygen. Pure oxygen is sometimes inhaled, under the advice of a doctor, by those who have weak lungs.

For a long time it was thought that nitrogen had no other use than to dilute the oxygen. Now it is known that tiny plants, so small that they are invisible, called **bacteria,** live upon the roots of some of the larger plants and absorb the nitrogen from the air. This they change into material which is needed by the larger plants. This is one example of the good which bacteria do for us. Later we shall learn that they help us in many ways.

The larger plants cannot take in the nitrogen until it has been changed by the bacteria, and many of the plants could not live if it were not for the bacteria.

The little lumps upon the roots of the plant in the illustration are called **nodules.** Each nodule is the home of bacteria. The illustration is the root of the garden-pea, but there are nodules upon the roots of many other plants and trees. Whenever you see these nodules you will know that there are many helpful bacteria within them.

The kind of food which the plants form from the material supplied by the bacteria is the source of our strength. When we study plants and food we shall learn more about these bacteria and their work.

32. Carbon Dioxide.

The amount of carbon dioxide in the air varies according to the location. Near factories there is a larger amount than in the open country, or on the ocean, while in a room where there are many persons the amount may become very great. This shows that fires produce it and animals exhale it. In the open country, air contains only three or four parts of carbon dioxide in ten thousand parts. The gas is a combination of oxygen and **carbon.** Coal, coke, and charcoal, all of which are fuels, are chiefly carbon. If the air of the room contains eight to ten parts of carbon dioxide in ten thousand parts of air it is unfit for us to breathe. Since exhaled air contains four hundred parts in ten thousand, it can easily be seen that there should be, not only a supply of fresh air, but the stale air should be removed continually. In addition to carbon

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dioxide we exhale small, invisible particles of decayed animal matter which also are poisonous unless diluted with plenty of fresh air. You all know the story of the Black Hole of Calcutta, and the fatal results from the lack of fresh air.

Carbon dioxide has its use and it is a most important one. Plants absorb it and break it up into its parts, carbon and oxygen. The plants keep the carbon, making wood of it, and give out the oxygen to the air again. Thus plants purify the air. For that reason we should have plants in our school rooms and houses. Plants owe their ability to take in carbon dioxide to the green coloring matter in their leaves and stalks. We have learned that the sunlight causes plants to be green, and so you see that it is the sun which causes plants to grow. That is why plants grow in the direction of the sun.

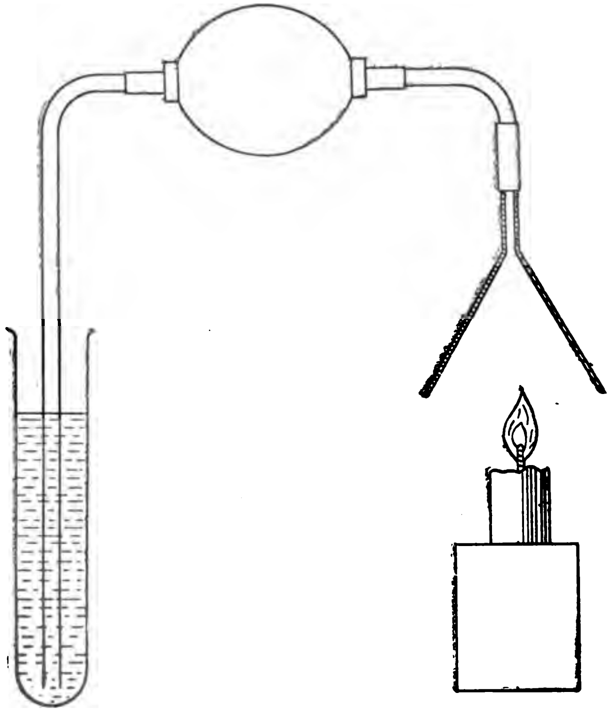
Experiment 41.—Carbon Dioxide from Combustion and from the Breath.

Apparatus: Candle, funnel, syringe bulb, glass tube, 10″ long, test tube.

Materials: Limewater (all the slaked lime that will dissolve in water; use the clear liquid only.)

a. Arrange apparatus as shown in the illustration, light candle, and force the gases which come from the candle into the limewater. What happens? What caused the change?

b. Blow out candle and repeat. In this case it is the air of the room which is being forced into the limewater. Does the change take place?

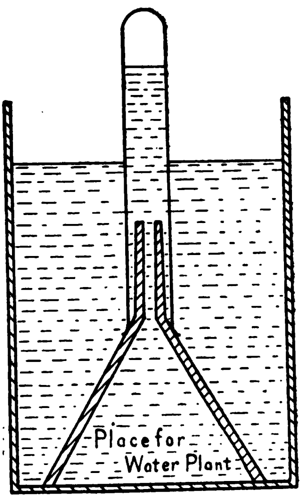


c. Take the apparatus out of doors and repeat. Do you finally see any change?

d. Now repeat (b.) and (c.), counting the number of times it is necessary to squeeze the bulb in order to obtain the same result. Divide the number of times it takes indoors by the number of times required out of doors. The result will show about how much more carbon dioxide there is indoors than out of doors. If the room is properly ventilated there should be little difference. Is the schoolroom properly ventilated?

e. Blow through the glass tube into some limewater. Do you think that you exhale the same gas as a candle produces?

The illustration shows a method of collecting the oxygen which is given off by a plant. In this case it must be a water plant, but oxygen is given off by all vegetation. If you wish to perform this experiment you must collect some water plants and place them in the bottom of a large dish. Cover them with a funnel, which may be made of tin, and fill the dish until the top of the funnel is covered with water to a depth of one inch. Take a test tube, fill it with water, cover the end with your thumb, and invert it in the dish, not letting



any water escape. Slide the test tube over the end of the funnel and set the whole apparatus in the bright sunshine. In a few minutes you will see bubbles forming, and in a day or two, the test tube will contain enough oxygen for a test. To remove the test tube lift it from the funnel, putting your thumb again over its mouth, while it is under the water, and remove from the water. Turn the test tube right side up,

keeping the thumb tightly in place. Test for oxygen. How will you do it? Is it oxygen? How do you know?

33. Respiration. The Necessity for Pure Air.

Breathing consists of inhaling and exhaling. Breathing is also called **respiration.** Do you know how many breaths you take in a minute? How can you find out? Do you always take the same number of breaths in a minute? What makes you breathe faster sometimes? Your heart beats faster when you breathe faster. A grown person, or **adult,** breathes 18 times a minute, not exercising, and his heart beats 72 times a minute, or four times the number of breaths. Young persons breathe faster and their hearts beat faster. Usually the heart beats four times for each breath.

We should breathe through our nose because it is a sort of sieve which keeps the dust from passing on to the lungs, and it also warms the air a little before it reaches our lungs. If persons find trouble in breathing through the nose they should consult a doctor.

The amount of air which we ordinarily inhale and exhale at each breath is 30 cubic inches. When we draw a long breath, or "heave a sigh," the quantity of air which we inhale or exhale is about 130 cubic inches. By trying, we can exhale about 100 cubic inches more. Even then there remains about 100 cubic inches which cannot be exhaled. The amount of air which the lungs hold is called their **capacity.** All persons do not have the same lung capacity, but where the capacity is less than it should be, it may be increased by breathing exercises and the right kind of physical exercise.

Experiment 42.—The Capacity of the Lungs.

Apparatus: Large bottle, holding at least a gallon, cork stopper to fit, large pan, holding at least two gallons, piece of rubber tubing three feet long, piece of glass tubing which has had its rough edges rounded off in a flame.

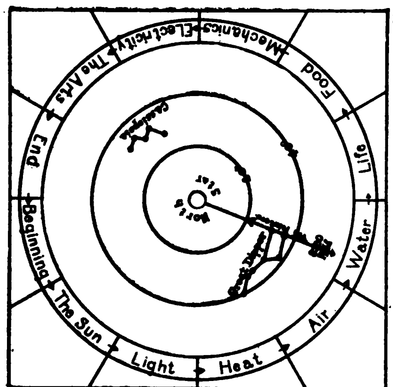
a. Fill the bottle full of water, insert the stopper and invert in a pan in which there is about two quarts of water. Remove the stopper and slip one end of the rubber tubing up into the bottle, which should be tipped a little to one side, and held there, in order not to jam the tubing. The glass tubing should be inserted in the other end of the rubber tubing to serve for a mouthpiece, which may be washed before each pupil uses it. Take several long breaths before measuring your lung capacity. Then take the longest breath possible, place the tube in the mouth, and blow hard. Keep on blowing until you cannot exhale a bubble more. **Immediately** remove the rubber tube from the bottle and estimate your lung capacity. There are 231 cubic inches in a gallon. If 100 cubic inches of air still remained in your lungs, what is the capacity of your lungs?

The amount of air which is needed per minute, in a room in which there are several persons, cannot be found out by multiplying the number of cubic inches used in each breath by the number of breaths per minute, and by the number of persons in the room. We must remember that the air which we exhale contains four hundred parts of carbon dioxide in ten thousand, while the proper

amount of carbon dioxide is no more than eight or ten parts in ten thousand. Now 400 is 50 times 8. This means that one breath spoils 50 times that amount of air, not only for others but even for ourselves. For this reason it is very necssary to have a large supply of fresh air. If there are lights burning in the room, such as kerosene lamps or gas, much more air is needed. An ordinary light spoils as much air as four persons in the same time. Electric light does not affect the air.

Review Questions, 18.

1. Why does pouring hot water into a glass dish break it? Would there be any difference if the glass were thin?
2. What is the result of incomplete combustion? Why is it not wise to allow incomplete combustion?
3. Why should a person not run if his clothing is on fire? What should he do if he is alone?
4. What kind of clothing is most liable to burn?
5. What is the composition of the air?
6. What would happen if there were no nitrogen?
7. How does carbon dioxide get into the air?
8. At the ordinary rate of breathing, how much air will twenty pupils breathe in half an hour? How much air will they spoil in the same time?
9. Find the number of cubic inches of air in your schoolroom and tell how many times it must be changed in every half hour in order to give you enough fresh air, if you were the only person in the room.
10. Solve Problem 9 for the number of persons in your room.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WATER.

34. Water is a Liquid.

A block of wood, or a stone, has a shape which does not change. What is the shape of a quart of water? Water will fit any dish that you put it into, and thus has no shape of its own. Anything which has a shape which does not change is called a **solid.** If the material fits the dish into which it is put and leaves no empty spaces, it is a **liquid.**

While water is a liquid and fits perfectly every dish into which it may be put, there is one part which is always the same. This is the top of the water, called its **surface.** The surface of water is always flat, or **horizontal.** Another name for horizontal, is **level.** All parts of a horizontal, or a level line are the same distance from the center of the earth. If we want to make the floor of a house level we can do so by means of a horizontal surface of water.

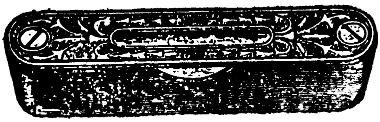
Experiment 43.—The Level.

Apparatus: Pie tin, small round bottle and stopple.

a. Half fill the pie tin with water and place it upon the board which you are to make level. If the water does not come up the same distance all around the tin, when it is on the board, the board is not level, or horizontal. Put little pieces of wood or stones, under the low sides of the board until the water is at the same height all around the tin. Can a board be horizontal in one direction, say north and south, and not horizontal in

the east and west directions? Is there any difference between being level and being horizontal?

b. Half fill the little bottle with water and lay it upon its side on a board. When the surface of the water is the same distance up from the side of the bottle, all along, the board is horizontal in the direction of the length of the bottle. How can you make a board level by means of the bottle? The bottle is called a **level.** A simple level is shown in the illustration. In this level the tube is curved so that the air bubble is always at the highest part.



A block of wood, or a stone, will stay where you put it; water will run off. All liquids act in the same manner and are said to **flow.** If the water faucet is gradually shut so that the flow of water becomes less and less, the stream will suddenly break into drops. How would a rainstorm be if water did not break into drops? Water-drops are all the same size unless the drops come together. Do raindrops ever come together?

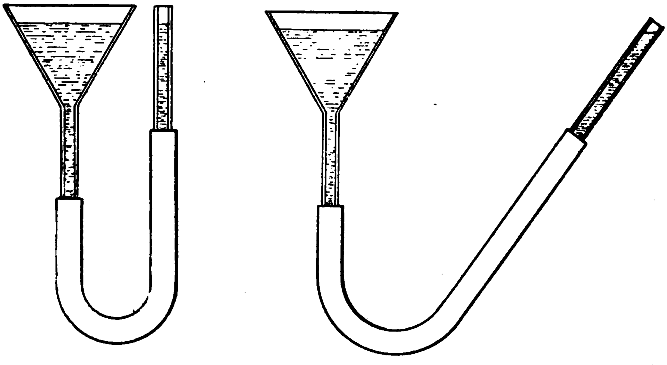
On account of the flowing of water there is a saying, "Water always seeks its own level." This means that the surface of water is at the same level everywhere if the water can flow freely between all parts.

Experiment 44.—*Water Seeks its own Level. Size of Drops.

* It is desirable to take Sec. 58 before performing this experiment.

Apparatus: Funnel, rubber tubing, glass tube to make apparatus as shown in the illustration, medicine dropper, graduate (50 c. c.), small dish.

a. Fill the funnel and tube with water and hold the



funnel and tube in various positions. What do you notice in regard to the level of the water in the funnel and the level of the water in the tube?

b. Fill the medicine dropper and carefully count the drops which are needed to make 5 cubic centimeters. In reading the graduate it must be placed on a level table and the reading must be taken with the eye on a level with the surface of the water. Read the lower surface of the water. How many drops in one cubic centimeter? If there are 946 cubic centimeters in a quart, how many drops of water are there in a quart?

35. Water can Pass into Some Things.

If we put a sponge into water some of the water goes into the sponge. The same thing is true of clothing.

We know that if we step into water it soaks into and through our shoes. All bodies which allow water to pass into them or through them are called **porous,** on account of many little holes in them which are called **pores.** When porous bodies take in water we say that they **absorb** water. There are other bodies which are porous although they do not seem to be so unless we experiment with them. A brick is very porous, and so are many rocks. As you know, the ground is porous, or the rain would not sink into it.

Experiment 45.—*Porous Bodies Absorb Water.

Apparatus: Balance, weights, cake pan.

Materials: Sponge, cloth, brick, porous stone.

a. Weigh the sponge dry, let it soak in water and weigh again. What is the gain in weight? How much water could a pound of sponge take in?

b. Repeat with the brick. The brick should remain in the water for a full day.

c. Repeat with the cloth and porous stone.

The only reason that some bodies are porous is because they contain little holes, or pores. If we wish to keep the water out of a body we must close the holes, just as we close the gate to keep out the dogs or other animals. Preparing material so that it will not permit water to enter is called **waterproofing**. See Section 74.

Experiment 46.—To Make Porous Bodies Waterproof.

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* Section 59 should precede this experiment.

Apparatus: Burner, ring stand, wire gauze, tin dish.

Materials: Piece of cloth, 4″x5″, paraffin.

a. Melt the paraffin by gentle heat and dip the cloth into it. While the paraffin on the cloth is still warm, shape the cloth into a four-sided box. When cold it should hold water. What keeps the water from going through the cloth?

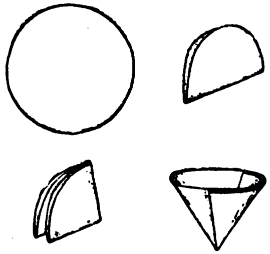
Rubber is the material which is commonly used to fill the pores of porous material, in order to make it waterproof, as rubber is not altered by ordinary changes in temperature. Do you think that your box would hold hot water?

While it is not pleasant to have water come through our clothing or even our houses, the porosity of materials has its use. Water which passes through the small pores has lost a large amount of its dirt. The separation of dirt from water, by means of porous bodies, is called **filtration**, and the porous body is called a **filter.** All water which comes from the earth in springs and wells has been filtered by passing through the porous ground. We can filter water, where necessary, by means of porous dishes or porous paper.

Experiment 47.—Filtration.

Apparatus: Funnel, funnel-holder (cut a hole in the small end of a chalk box), test tubes.

Materials: Sawdust, sand, filter paper.



a. To use filter paper, fold it in halves and then again in quarters, as shown in the illustration. Separate one thickness from the other three and place in funnel. Mix some sawdust, sand and water. Then filter. Does the water pass through clear?

Review Questions, 19.

1. What are two causes of the variation in the heat which we receive from the sun?
2. What causes contraction?
3. What part of the room is the warmest, near the ceiling, on the level of your head, or near the floor?
4. What are the advantages of deep breathing? How can you prove your answer by figures?
5. Name the parts of the air that are used by plants, stating how they are used, and the parts of the air which are taken in by animals, giving the use of each part.
6. If you were given a long rubber tube, which would reach across the room, and two glass tubes to fit the ends of the rubber tube, tell how you could put two shelves on the opposite sides of the room at exactly the same level.
7. How could you find out whether a body is porous?
8. Name all of the porous bodies you can think of and state the advantages or disadvantages which are due to their porosity.
9. What is meant by waterproofing. Give some examples of waterproofing.

10. Why is water from springs usually clear, while water in rivers is dirty?

36. Solution.

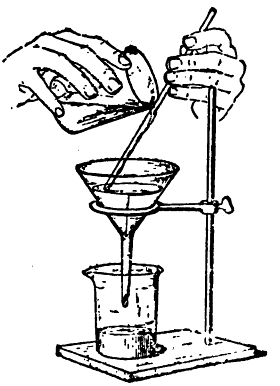
When we put sand or sawdust into water we could still see it. Can you see sugar when you have put a little into water and have stirred it well? If a solid disappears, when put into a liquid, we say that the solid **dissolves,** and we call the result a **solution.** Not only does water dissolve solids but it can also hold gases in solution. Any liquid which can dissolve solids or gases is called a **solvent.** In Section 28 we saw that water can hold considerable air in solution if the water were cold. The best way to learn more about solution is by experimenting.

Experiment 48.—Solution and its Oddities.

Apparatus: Two glasses, tin spoon, burner, tin cans, thermometer, funnel, filter paper, glass rod.

Materials: Sugar, salt, baking soda, cream of tartar, ammonium chloride (commonly called sal ammoniac).

a Fill a glass **full** of water. Very slowly add some sugar while carefully stirring. Note that it is possible to add considerable sugar without making the water overflow. Now add some salt in the same way to the same water. Can you do it without making the water overflow? What is one of the oddities of solution? Try filtering the solution. Do the sugar and the salt pass through? The method of pouring liquids from a glass is shown in the illustration.



b. Put a little cold water in one glass and the same amount of hot water in another glass. Now see how much sugar will dissolve in the cold water and how much in the hot water. When a solvent holds all of a solid it can, the solution is said to be **saturated** for that temperature. Which solution becomes saturated first, the hot one or the cold one? Which is better for dissolving solids, cold water or hot water?

c. Fill a glass one-fourth full of cold water, take its temperature, and then add half as much sal ammoniac as there is water. Stir rapidly and immediately take its temperature. What is another oddity of solution? Can you explain (b.) above, now that you have done (c.)? Do you think that the solution is saturated? Why?

d. Put a little dry baking soda and a little dry cream of tartar into a dry glass. Nothing will happen. Now add some water. What happens? Solution permits the action of one material upon the other. The gas is carbon dioxide and it is this gas which makes soda biscuits rise.

Water owes its power of removing dirt to the fact that it can dissolve so many substances, but there are many kinds of material which water cannot dissolve. Fortunately for us there are other solvents which can dissolve some of these. Two common examples of special solvents are alcohol and gasolene. We should be very careful when we are using either of these solvents.

not to be near a fire, or even be in the same room with a fire or a burning lamp, for both are very easily set on fire. Gasolene produces a gas which may be set on fire by a flame although several feet away.

Experiment 49.—*The Use of Gasolene and Alcohol as Solvents.

Apparatus: Two small bottles with stoppers.

Materials: Gasolene, alcohol, kerosene, pieces of cloth, grease (lard), rosin, pitch.

a. Shake a little grease with water in a bottle. Does the grease dissolve in the water? Pour off the water, add gasolene and shake again. What is the result?

b. Put a very little grease on a piece of cloth. This will make a grease spot. To remove the grease spot the space all around the spot should be wet with gasolene before putting the gasolene upon the spot itself. If gasolene is put upon the grease first the grease will spread and leave a ring after the spot has been removed. Try putting the gasolene upon a grease spot on a second piece of cloth and notice the familiar ring when the gasolene has evaporated.

Shake a little powdered rosin with water in a bottle. Does the water dissolve the rosin? Pour off the water, add some alcohol, and shake again. What is the effect of alcohol upon the rosin? Pour the result upon a smooth piece of wood and allow the alcohol to evaporate undisturbed. How does the wood appear? Rosin is used in cheap varnishes. Do the cheap varnishes scratch easily?

Put some pitch upon a piece of cloth and remove it with kerosene. It may be necessary to allow the cloth

* This experiment may be omitted or performed only by the teacher.

to soak in the kerosene for some time. Pitch may be removed from the hands with kerosene. The kerosene may then be removed with soap and water.

37. Crystals.

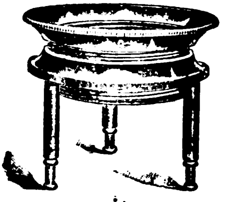
We have seen that some solids can disappear in solution. Do you think that they can come out of solution and appear again? The only way in which we can get a solid out of solution is to drive off the water by means of heat, called **boiling,** or we can let the water pass off slowly and without bubbling. This last method is called **evaporation.** Let us learn about this by some experiments.

Experiment 50.—Crystallization.

Apparatus: Burner, ring stand, wire gauze, two beakers, three glasses, stirring rod, deep dish.

Materials: Alum (powdered), copper sulphate, common salt, string.

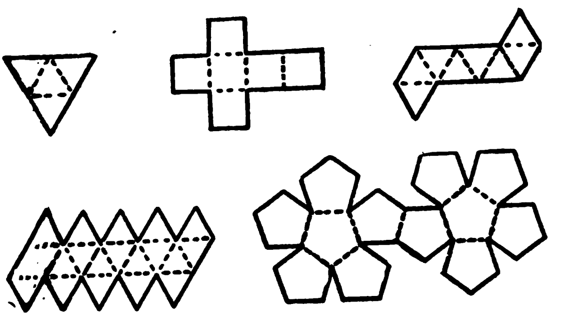
a. To a little water add one half as much powdered alum and stir for a few minutes. Does it all dissolve? Now put it on the ring stand, resting it upon the wire gauze, and heat it until it boils. Does heat aid solution? Place the beaker containing the solution, in a dish of cold water and stir it constantly until cold. What happens? Heat the beaker again until all of the alum has dissolved and then place it again in the dish of cold water, but do not stir it or touch it until it is cold. What is the result? What you see are **crystals.** Which method produces the larger crystals, rapid cooling or slow cooling? Keep the crystals.



b. Repeat (a.), using the same amount of water but using three-fourth as much copper sulphate as water, in the place of alum. What are your results? Note the shape of the crystals. Are they the same as the alum crystals? A microscope, such as is shown in the illustration will help you, although it is not a necessity.

c. Make a saturated solution of common salt, one of alum, and one of copper sulphate. Place in separate glasses and in each solution hang a piece of string from a little stick placed across the top of the glasses. Set aside for a few days. The water will evaporate and leave the solids. Are all the crystals the same shape? The crystals of any one substance are always the same where they have formed slowly and have had plenty of room in which to form. Can you tell the difference between a salt crystal and an alum crystal?

There are many crystals in nature although there are but six different kinds. We may imitate a few of the crystals by cutting out the shapes, as shown in the illus-



trations, from thick paper, folding on the dotted lines, and pasting their edges together by means of strips of paper.

38. Water for Drinking.

There is hardly any pure water as it occurs in nature. On account of the great power which water has to dissolve so many substances, there is usually some material held in solution. Fortunately for us, many of the substances found in water are not harmful to man, while some of them are very helpful. The harmful substances which are dissolved in water are usually so bad tasting that there is little danger from them, for no one will drink the water.

While the dissolved material is usually harmless, there is great danger in drinking impure water. This is due to a kind of plant life we have already become acquainted with in Sections 13 and 25. Some of these, which we learned were called bacteria, may cause typhoid fever. Although the water is clear and seems pure, the bacteria may be present. On the other hand, dirty water may be free from bacteria and be harmless. Wells should be so located that drainage cannot possibly reach them, for decayed animal matter is what these bacteria live upon. Since water can pass through the porous rocks, wells must be far away from open drains and stables.

The body requires a large amount of water and most grown persons do not drink enough. The more water we drink the better are the wastes carried from the body. We have learned that while water can dissolve many

things, a limited amount of water can dissolve only a limited amount of any one solid. Thus, unless we drink a sufficient amount of water, the impurities which are produced in our bodies by the wear and tear of living, or those which are taken in with food, will not be carried off rapidly enough. Unless we are warm we should drink all the water we desire. It is best to drink slowly and often, rather than rapidly and in large quantities.

While the drinking of a large amount of water is very desirable, and even necessary, yet there are other common drinks which are harmful. Any drink which contains alcohol, such as beer, wines, whiskey, brandy, and many others, cannot fail to harm a person to some extent. Alcohol is a poison, and even a small amount of a poison will have some harmful effect. Some persons who use drinks which contain alcohol may seem to be unaffected, but they do not know how much greater progress they might have made if they had left alcohol alone. Alcohol should always be considered as a drug.

Compared with alcohol, coffee and tea are not very harmful to grown persons unless used to excess. Young persons should not drink either coffee or tea until they have completed their growth. Even grown persons should be careful not to drink too much of either coffee or tea. A person who uses too much of these drinks becomes nervous and irritable, and his eyes are often affected.

Review Questions, 20.

1. Why is it warmer in summer than in winter? Why is it warmer near noon than at sunrise or sunset?

2. If your clothing should be set on fire, what would you do. What would you do if you saw the clothing of another person burning?

3. Why are you sure that there must be air in water?

4. How much air does a person spoil by breathing for one hour?

5. What is the best kind of light to use in our houses? Why?

6. Why are brick houses sometimes damp? Could the dampness have been prevented?

7. Why do we stir or beat frosting for cake for a long time? If we did not beat fudge what would be the result?

8. What is meant by evaporation? What causes evaporation to be more rapid?

9. When do we need the more water for drinking, when we have been perspiring a great deal, or hardly perspiring at all?

10. Explain how harmful drinks may harm us although we may not notice the harm.

39. Water for Cleansing.

The most important use for water is for drinking. We shall see in the next section that plants, as well as animals, require a large amount of water in order to live. The use for water which is next in importance to its use for drinking and for plants, is its use for cleansing. Water owes its power of cleansing to its ability to dissolve so many substances.

We know that if water has some dissolved substance

already in solution it will not dissolve other substances as readily as will pure water. If water has very little dissolved material in it, it will cleanse easily. We call such water **soft.** Rain water which has fallen after it has been raining for some time, is very soft. Why? Water obtains its dissolved material from the ground. Water which contains dissolved substances is called **hard.** Soft water makes suds with soap very easily while hard water does not. Since soap has the power of acting with the water to dissolve or loosen dirt, if it does not dissolve in the water and form suds, the water is **hard** to use for washing. Cleansing is much easier with soft water than with hard water.

Experiment 51.—*Hard and Soft Water. Soap.

Apparatus: Burner, ring stand, tin cup, pint bottle with stopper.

Materials: Distilled water, powdered or shaved soap.

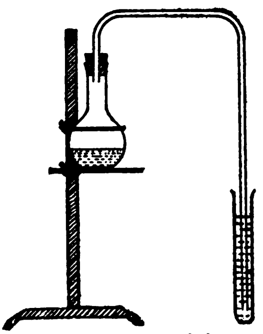
a. Measure the smallest amount of soap which will just begin to make suds when shaken with a half pint of distilled water in a pint bottle. This will give you a **standard,** for distilled water is absolutely pure and will make suds with the least amount of soap. Any other water will use more soap.

b. See how much soap is necessary to produce suds with a half pint of ordinary water. Take another half pint of the same kind of water which has been boiled for at least five minutes. Does it take more or less soap to make suds with the boiled water than with the unboiled water? Hard water which can be made soft by boiling

* See Experiment 79.—Distillation.

is called **temporarily** hard. If the water is not rendered soft by boiling it is called **permanently** hard. Was the water you used temporarily or permanently hard, or was it soft?

Since hard water requires more soap than soft water, in order to produce suds, the use of hard water for cleansing is more expensive than the use of soft water. Water which is temporarily hard contains carbon dioxide, as well as a solid. When we boil it the heat drives off the gas and the solid collects on the sides and bottom of the dish; thus both are removed on account of the heat and the water becomes soft. How could you show that carbon dioxide is driven off from temporarily hard water?



We wash our clothing to remove the visible dirt so that the clothing will be neat and clean. At the same time we remove the invisible dirt which is usually more harmful than the visible. The invisible dirt is composed chiefly of material which has been left by the perspiration when it evaporated, particles of dead skin and bacteria. Since the perspiration comes from our bodies it is of great importance that we keep our skin clean—not alone visibly clean but really free from anything which can be washed off. The mouths of the tubes through which the perspiration comes, called **pores**.

should be kept clean and open by frequent baths which ought to be taken daily, if possible.

Dirt cannot be removed completely without the use of soap. There are two kinds of soap—laundry soap and toilet soap. Soap which is suitable for washing clothes and for general housecleaning is usually unfit to be used on the skin. On the other hand, toilet soap, which is intended for tender skin, would have little cleaning power if used on clothes. See Section 77.

40. Plants Need Water.

We all know that plants need water, for if we forget to water them they quickly wilt, and, if they go too long without water they die. If the plants have only wilted they soon take up the water and become stiff and vigorous again. In the next section we will learn the reason for this change. The amount of water which plants need is very great. The water is carried away from the leaves by evaporation,just as it is carried from wet clothes which are hung to dry. When we think of the very large surface of the leaves of a tree we will realize that the amount of water which can be given off is enormous. We call the giving off of water from the leaves of a plant **transpiration**. Transpiration takes place only on the under side of leaves.

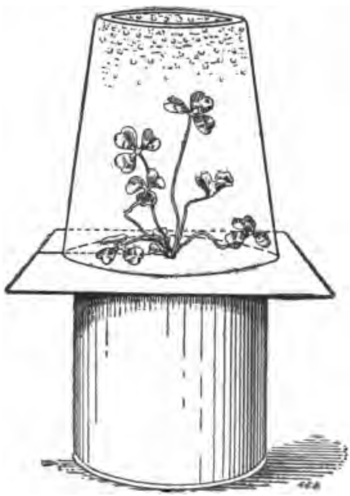
Seeds will not begin to open unless they are supplied with water. Then they swell until they burst, and the young plant comes forth. The amount that seeds swell is always a surprise, as you know if you have ever "put beans to soak."

Experiment 52.—The Effect of Water upon Seeds and Plants.

Apparatus: Two glasses large enough to cover a small plant.

Materials: Beans, a plant in a can or pot, two pieces of cardboard 6″x6″.

a. Fill a glass one-half full of beans and then completely fill the glass with water. Set aside for twenty-four hours and tell what happened. The beans may be dried by putting them in the sun.



b. Cut a slit in each piece of cardboard from the middle of one side to the center. Slip the pieces around the stem of the plant from opposite sides and press them down upon the top of the flower-pot. Cover the plant with the glass and set it in the sun. The experiment should appear like the illustration. What collects on the glass after an hour or so? Where does it come from? Why were the pieces of cardboard used?

41. Capillarity.

The word "capillary" means "like a hair," that is, very fine. Capillarity is the strange action of liquids in

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tubes which are as fine as a hair, or even finer. Let us perform some experiments which show capillarity and talk about it afterwards.

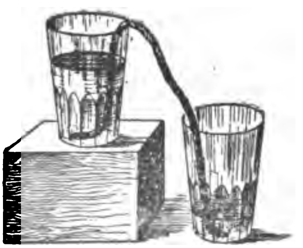
Experiment 53.—Examples of Capillarity.

Apparatus: Several 6″ pieces of glass tubing of different diameters, two glasses, lamp wick, block of wood.

Materials: Cube sugar, red ink.

a. Fill one of the glasses with water and place the tubes in it. Describe how the water goes up the tubes. A little red ink, added to the water, will make it easier to see the water in the tubes. In which tube does the water go the highest? You can make a very fine glass tube by heating a short piece of ordinary glass tubing in the flame of a wing burner, and then suddenly pulling the two ends as far apart as you can reach. Water will go six or eight inches up such a tube. Try it.

b. Fill one glass with water and place it upon the block of wood. Now wet the lamp wick thoroughly, wring it as dry as possible and bend it over the edge of the glass so that it reaches the bottom of the glass. while the other end falls into the other glass placed near the block. The lower glass should be empty. Tell what happens in a few minutes. What is this an example of? The oil in a lamp reaches the flame in the same way.



c. Dip one corner of a lump of sugar in some colored

water and see how quickly the water passes through the whole lump.

Capillarity acts in all directions. Thus if we lay a lamp wick flat upon a table with one of its ends in a little pool of water the other end will soon be wet. Capillarity acts faster downward than in any other direction. Can you explain why this is so? When you put a drop of ink upon a blotter, how does it act? What causes it to act in this manner? Think of all the examples of capillarity you can. Bodies must be porous in order that there may be the little holes in which capillarity may act. If we wish to stop capillarity we must close the holes.

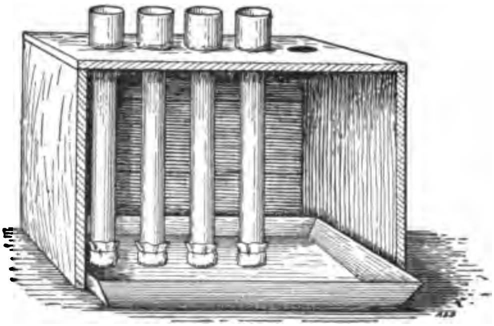
We have learned that water is necessary for plants and that the soil must be kept damp if we expect the plants to grow well. How do you suppose that the soil holds the water? Did you ever see water put into a saucer which was placed under a flower pot? How did the plant obtain the water? All soils are not the same in their ability to hold, or take up, water and the following experiment will show the right kind of soil to use for flowers.

Experiment 54.—How Water is Held in the Soil.

Apparatus: Chalk box, or other small box, with four or five holes in one side large enough to hold student lamp chimneys, four or five student lamp chimneys, with cheese cloth tied over their smaller ends, pan.

Materials: Gravel, sand, coarse soil, fine soil, vegetable mold.

a. Arrange the apparatus as shown in the illustration and have the water cover the ends of the chimneys. Fill each chimney with a different kind of material. In which does the water rise the highest? In



which does the water rise the fastest? Which soil would you prefer to have on your farm, if you were a farmer?

The farmer is very much concerned with capillarity and we will study it some more when we come to Section 54, in which we shall learn that the farm is just like a workshop. Capillarity, besides bringing the water to the roots of plants, is one of the causes of the rise of sap in the stalks of plants and trunks of trees. The evaporation of water from the leaves aids the rise of sap, just as the burning of the oil in lamps aids the capillarity in the wicks in bringing the oil to the flame. The next

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experiment will prove that capillarity acts in plants, as well as showing where the sap rises.

Experiment 55.—Capillarity in Plants.

Apparatus: Glass, knife.

Materials: Red ink, twigs of any tree having flat leaves.

a. Cut a few twigs and put them immediately into some water which is strongly colored with red ink. Place the glass in the sun and in a draft of air, if possible. At the end of ten minutes remove one twig and split it lengthwise. Where did the colored water go? Remove another twig at the end of half an hour and examine in the same way. Leave another twig for a full day. How do the leaves appear? How did the colored water get through the stem? Make a drawing of the twig, split lengthwise, showing just where the colored water passed through it.

If the stalks of plants are not woody, they receive their stiffness from the capillary tubes in them being full of water. If the plants do not receive enough water the tubes become empty and the stalks flabby. We say that the plants wilt. When is a garden hose stiffer, full of water or empty?

Review Questions, 21.

1. What was the position of the Great Dipper last night at eight o'clock?
2. What are the uses of nitrogen?

3. How is carbon dioxide harmful and in what way is it helpful?

4. What are some of the oddities of solution?

5. Name all the uses of water. Which one is the most important?

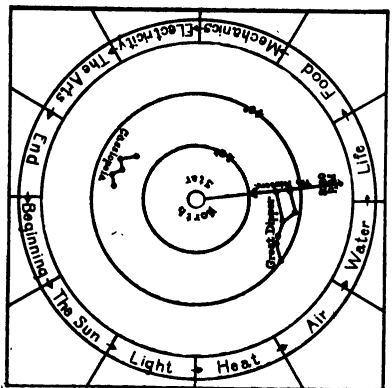
6. Why is soft water cheaper to use than hard water although the same price is paid for each?

7. How can you prove that plants obtain water from below the surface of the ground? How do they do it?

8. Why is wet earth heavier than dry earth? Which kind of earth would be heavier when wet, a fine earth or a coarse earth? Explain.

9. Why do farmers break up the soil so that it is fine, before they plant?

10. Why do our feet become wet when we walk on the wet sidewalk?


Mechanics
Electricity
The Arts
End
Beginning
The Sun
Light
Heat
Air
Water
Life
Food
North Star
Great Dipper
Cassiopeia

THE GUIDE

PLANTS AND ANIMALS.

42. The Beginning of Plant Life.

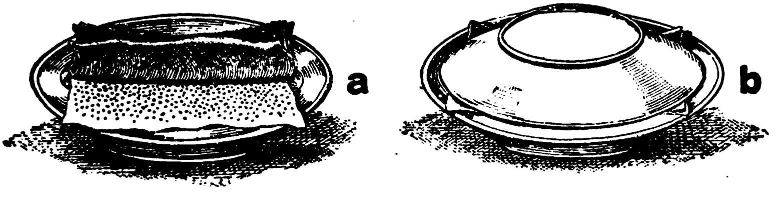
The beginning of all plant life is in the seed. As long as the seed remains dry the little plant rests, but as soon as water is absorbed by the seed it cracks open and the tiny plant begins to grow. Let us examine some seeds and learn how the plant gets its first start.

Experiment 56.—The "Pocket Garden."

Apparatus: A plate and a saucer.

Materials: Blotting paper, seeds of beet, bean, corn, pea, radish, squash.

a. Lay a square of blotting paper upon the plate



and upon it place the seeds. Cover the seeds with another square of blotting paper and moisten both with water. Now cover all with the saucer. Keep the blotting paper moist but do not have the seeds under water.

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Keep in a warm place and examine once a day, noting the order in which the seeds sprout.

b. Make several drawings of each seed, showing the method by which the baby plant comes out of the seed.

c. Write a description of the roots, stem, and leaves of each plant.*

* Note to teachers: This work may be extended over considerable time and many other seeds may be sprouted. The drawings and descriptions would make a good supplement to the English and art work.

43. The Testing of Seeds.

All seeds do not sprout because all of them are not perfect seeds, or have been harmed in some manner. It is of very great importance to the farmer that he obtain good seed, for otherwise he might plant many seeds which would not grow. Thus the crop would be less than it should be and the farm would not be as productive as it might otherwise be. Most farmers now test their seeds because they have learned that a little trouble in the beginning will save them much money in the end. The testing of seeds to see if they will all sprout is called the **germination** test.

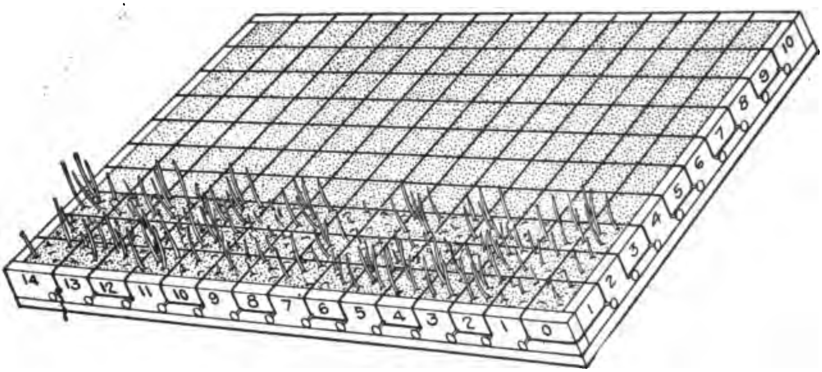
Experiment 57.—*Germination Tests.

Apparatus: Shallow wooden tray, tacks, string.

Materials: Sand, seeds of various kinds from various stores.

a. Mark off the sides of the box into two-inch spaces and drive a tack at each mark. Now lace the piece of string backward and forward so as to divide the open end of the tray into squares, two inches on each side.

* Adapted from Farmers' Bulletin 409, U. S. Dept. of Agriculture.



Mark the sides of the tray as shown in the illustration and fill the box with dry sand, heaping it a little. After scraping off the sand with a straight stick the tray is ready for planting.

b. Plant at least five seeds in each square and plant as many kinds of seeds as possible. The seeds should just be covered by the sand. The same kind of seeds which are bought at different stores, or obtained from different places may be considered as different seeds. On a page in your note book mark the kinds of seed and the place from which you obtained them, together with the number of the square in which you planted them. Count the number marked at the left end of any row as **tens** and add to this the **unit** number which is marked at the right end of any row. Do not count the zero.

c. Water the sand, after planting the seeds, by pouring the water upon a piece of paper placed on the sand. Keep in a warm room, watering now and then, and watch for the little plants. In about a week all of

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sand. Keep in a warm room, watering now and then, the seeds which are good will have sprouted. Good seed should have every seed sprout.

44. The Proper Planting of Seeds.

While good seeds are necessary, if they are not properly planted they will not grow well and perhaps not at all. If the seeds are planted too deeply they may die before they can reach the light, while if they are not planted deeply enough they may become dried by the sun and killed by too much light upon the delicate roots. The depth of planting of seeds varies from one-eighth of an inch, in the case of celery seeds, to four inches in the case of the white potato. If the ground is very damp the seeds may be planted less deep than if the ground is quite dry. Why? Sometimes seed beds are shaded from the sun. Can you explain the reason?

There was no way for man to discover the proper depth of planting except by experimenting. We can now use the knowledge that has been acquired by others and thus save time. However, let us try the experiment on a few different seeds in order to see why it is that the plants do not grow well if the seeds are not planted at the proper depth.

Experiment 58.—*The Proper Depth of Planting.

Apparatus: Several deep, wide-mouthed bottles, such as pickle bottles, black cloth to cover bottles.

Materials: Loam, seeds of various vegetables and flowers.

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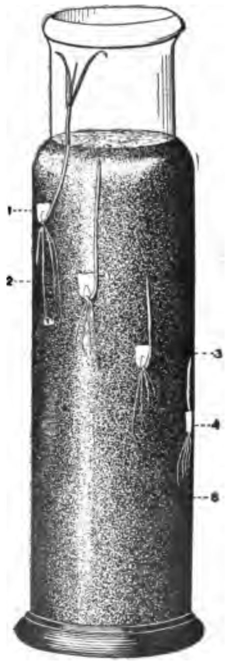
* Adapted from Farmers' Bulletin 408, U. S. Dept. of Agriculture.

a. Sprinkle about an inch of loam in the bottom of the bottle and place one seed of each of four or five different kinds on the surface of the loam, next to the glass so that they can be seen when they are covered with loam. Then sprinkle about an inch more of loam and repeat with the same kinds of seeds as were used on the first layer. Repeat the process until the bottle is full. Other pupils may use different seeds. Water the loam so that it is moist but not wet. Cover the bottle, or bottles, with black cloth, so as to shut out the light from the seeds, keep in a warm place, and examine once a day. Do not let the sun shine upon the bottles.



b. When the seeds begin to sprout make drawings of the way in which the plant comes out of the seed and the way in which the root turns. Make drawings of what happens to those seeds which were planted too deeply. You will find that the seeds very near the surface may grow all right, but you must remember that the sun did not shine upon the loam. Measure the depth which you find is proper for your seeds, and obtain from the other pupils their best results.

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45. The Needs of the Plant.

We have learned quite a lot about plants and now we are going to gather the information together. Science study is different from some other studies because in science we learn a number of facts concerning something and then gather all these facts together and try to learn how they all are true at the same time. Then we can form an idea of how the subject studied must act and how it would act if conditions were different. This is called **drawing conclusions.** Let us study an example: We learned in Experiment 36 that air is necessary in order that plant roots may grow. Since plants start from seeds we might think that seeds would not sprout if they were not supplied with air. If we nearly fill a bottle with moist earth and plant a few beans or peas in it, and then stopple it tightly, it will be found that the seeds will not grow. Other peas and beans planted under the same conditions in an open bottle will grow. Then we can draw our conclusion that air is necessary for plant life of any kind. How do water plants get air?

We are always told to keep plants in a warm place so that they may grow well. Do you think that if seeds are not kept warm they will grow? Draw your conclusions from the last paragraph—and then try the experiment. Place some seeds in moist loam and put it in the ice chest, or try the experiment during cold weather. Light, which is so closely connected with heat, is also, necessary for green plants, as we learned in Section 11.

In the germination tests, which you are making, you are discovering that although water is necessary for plant life, the plants die if they are supplied only with water. They, like animals, require food and they obtain

their food from the ground. If the ground is not rich the plants will not grow well because they will not be able to obtain enough food. Farmers add plant-food to the ground, where the ground is not rich enough. Any plant-food which is added to the ground is called a **fertilizer.** All plant-food must be such as will dissolve in water after it is put upon the ground.

Thus plants need light, heat, air, water, and food. Do you think that you need much more in order to live?

Review Questions, 22.

1. Why do plants grow best in summer? Give several reasons. Why is the glass of greenhouses sometimes covered with white paint?

2. Why is it bad for a plant to soak the soil with water so that the water stands on the surface of the soil for several hours?

3. Why does water go into the soil?

4. If you were buying a farm how would you decide whether the soil was good?

5. Why do the plants soon die in Experiment 56? Which plants live the longer, those from large seeds or from small seeds?

6. What is the advantage of germination tests?

7. Why is the sand watered in Experiment 57 by pouring the water upon a piece of paper?

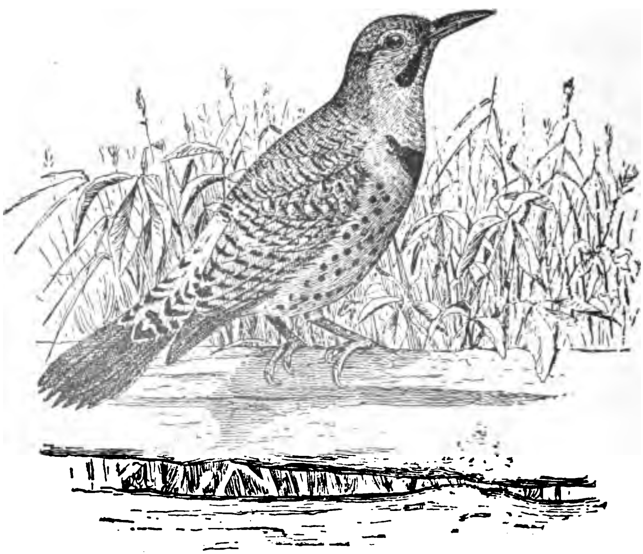
8. Why is it necessary to know the proper depth of planting? Do you think that a difference of a quarter of an inch would do any harm to a seed which should be planted two inches deep?

9. Name and discuss all the needs of a plant.

10. Name all your needs besides the needs of the plant and see if they really are necessary.

46. *Birds.

In the minds of farmers birds are closely connected with seeds. The birds visit the fields as soon as they are planted and the farmer views them with suspicion. The birds, as a rule, eat very few seeds of farm crops, and they are much more interested in getting the worms and insects which have been exposed by the cultivation of the land. Since many of the insects which the birds eat



Cut supplied through United States Department of Agriculture.

* See Appendix.

are those which harm the crops, the birds are really the farmers' friends. Nearly one-tenth of the crops are destroyed by insects, even with the birds eating all the insects they can. If the birds were destroyed it would be doubtful if a satisfactory crop could be raised. The birds do eat seeds, but they are very fond of weed seeds so that they help the farmer also in this case. Weeds can grow better than the crops, and they take the water from the soil which the crops need.

Not only do the birds help the farmer but they also protect the forests to a great extent. Many of the forest trees are easily attacked by boring beetles and ants. The harm which is due to these wood-boring insects is increased by decay which begins to take place around the holes. In Section 48 we will learn more about the decay of trees. The large illustration is the familiar woodpecker, called the flicker. Like other wookpeckers it is one of the chief preservers of the forests and should be protected in every way. The small illustration is the well-known phoebe whose chief food is harmful insects, the rest of the food being wild fruit.

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47. *Wild and Garden Flowers.

The names of the common garden and wild flowers should be learned and associated with them. The only way to do this is to bring a few flowers to school and compare them with the illustrations in the large reference book which tells all about them. Gradually you will learn the names of all the common flowers as well as some of the rarer ones. The best way to learn so that you will remember is to make a collection of the flowers and write a brief description on the paper upon which you mount each flower. Then you can always review your own work and often learn more than you would from just reading a book. The next experiment should be continued until there are no flowers of the neighborhood which you do not have in your collection. See which pupil can make the best collection, but remember that "The race is not always to the swift."

Experiment 59.—A Flower Collection.

Materials: Sheets of soft, unglazed paper cut 17"x11", folded so that they are 11"x8½", strips of gummed paper ¼" wide.

a. Take one of your flowers, which should have a long stem but not longer than ten inches, and several leaves, and compare it with the reference book. After you have learned its name and habits arrange it in the prettiest manner possible, on the right side of the fold, having the paper unfolded. Try to remember how the plant was growing and arrange it as it was, because the natural way is always the prettiest. Cut the gummed paper into lengths so that they will pass over the stems

* See Appendix.

and have a good hold upon the paper on each side of the stems, when pasted down. Do not use the strips too long nor too plentifully. The flowers and leaves should be fastened so that they cannot move, but too many strips do not look well. After a plant is nicely fastened, cover it with the left hand part of the paper and press under several large books until dry. Then write its name and description in the place on the right hand page where there is the most room.

48. *Trees.

The value of trees to man is very great. We have learned that trees take in carbon dioxide and give out oxygen. This is of more importance in our cities than in the open country for there are many fires in houses and factories, all of which are producing vast quantities of carbon dioxide. Although the wind blows part of this away and the rain washes some of it into the ground, yet it is most important that we have as many trees as possible in our cities. Trees, as well as all other plants, give off a huge amount of water by transpiration and change the climate of a locality very much. See Section 40. Trees also reduce the violence of winds. Finally, trees are beautiful.

While trees are of very great value in cities they are of still greater value to the nation in whose forests they grow. When rain falls upon bare ground most of it runs off, wearing the soil away and doing no good. After the rain is over there is very little water left in the soil, and this soon dries up in the bright sunlight. If the ground is dry there will be no streams or rivers soon after the

* See Appendix.

rain has ceased to fall, although the water which ran off the bare ground during the rain may have caused floods. If there are forests, however, the leaves gather much of the rain and cause it to drip slowly to the ground. There it is caught in the mass of dead leaves and twigs and cannot run away. Thus it slowly sinks into the ground until the soil is wet many feet deep. When the rain ceases the sun cannot cause the water to evaporate because the thick shade of the forest keeps it out. The water slowly passes away by capillarity and thus the streams and rivers flow for a long time.

The government of the United States has set aside vast forests called National Forests in order to regulate the flow of water, as well as to keep up a supply of wood. The older trees are cut and younger ones are allowed to grow in their places. The chief enemies of the forest are fire and insects. Men, called Forest Rangers, protect the trees against fire, and our friends the woodpeckers, eat the insects. The illustration shows how "frogstools" indicate that decay has begun. The frogstools live upon the trees where insects have made holes in the bark. Just as our skin protects us from bacteria so the bark protects trees from decay. The heart of a tree may be decayed and the tree will still live, for its growth is on the outside. In what part of the twigs did the red ink rise in Experiment 55? Each year a ring is added around the trunk of a tree, unless decay is taking place on the outside of it, and by counting the rings on the stump of a tree which has been cut down you can tell its age.

Just as with flowers, we should know the common trees by name. It is not possible to make a collection

of trees but we can collect the leaves and seeds and perhaps get pieces of the bark and wood.

Experiment 60.—A "Tree" Collection.

a. Collect the leaves of all the different trees you can find in the neighborhood and mount them in the same way as you mounted the flowers in the last experiment.

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Look up their names and habits in the reference book and write a brief description of each kind upon the paper upon which you have mounted the leaves.

b. Try to obtain pieces of trees with the bark on. Saw these lengthwise, and polish them with sandpaper, after they are thoroughly dry. Label them carefully. To keep the collection, a screw eye may be inserted in one end and the samples hung on hooks which are the right distance apart.

c. A collection should also be made of the seeds and seed cases of all the trees. These may be placed in small cardboard boxes which are properly labeled.

It would be a good plan for you to write some letters to pupils in other cities and states, telling them what you are doing and asking them to send you samples of flowers, leaves, wood, and seeds which grow there and which do not grow near your school. In return you would send samples which they did not have. Of course you would send your best work.

The seeds of trees grow in an interesting manner as you will see by the next experiment.

Experiment 61.—Planting Tree Seeds.

Apparatus: Box filled with sand.

Materials: Acorns and other soft-shelled nuts, seeds of the apple, pear, orange and lemon trees, and any other tree seeds which are easily obtainable.

a. Plant the seeds or nuts about one inch deep in the sand and keep it moist. When the seedlings have

come up they may be transplanted into tin cans filled with good soil, and allowed to grow. There should be openings in the bottom of the cans? Why? Make a drawing of how each kind of tree starts from its seed.

b. When the little trees are a few inches high they may be taken home and placed in the garden, unless they are trees which cannot live in your climate. In this case they must be kept in the house.

Review Questions, 23.

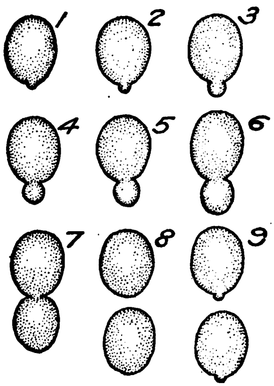
1. How can you show that plants need light?
2. What is a flame? How can you prove your answer?
3. Do all crystals have the same shape?
4. Name six of the harmful drinks. Do they always show the harm which they are doing?
5. What causes water to be hard?
6. How do birds help the farmer? How do they harm him? Which is greater, the help or the harm?
7. What is the good of knowing the names of flowers?
8. Parks have been called the "breathing places" of a city. Explain why this is a good name.
9. If all the forests were burned or chopped down what would be the effect upon the country?
10. Name all the advantages of having forests.

49. A Queer Plant—Yeast.

All the plants which we have studied, except bacteria, have been large enough to be seen. All of these visible plants have needed light, heat, air, water and

food in order to live. They have taken in carbon dioxide and given out oxygen. They have had leaves, flowers, stalks and roots, and have grown from seeds. Now we are going to study a very queer plant which has no roots, stalk, leaves, flowers nor seeds. This plant is called **yeast** and all its needs are sugar and water and a little heat.

Yeast plants are so small that they cannot be seen by the use of the simple microscope, but it is necessary to use a very powerful microscope. An ordinary yeast cake contains millions of these little plants. If sugar, water, and a little heat are supplied, each tiny plant begins to send out a little swelling called a **projection** which increases in size until it is nearly as large as the plant itself. Then it breaks off and becomes a separate plant. Such growth is called **budding**. The illustration shows the process of budding in nine stages.



When the yeast plants are growing they change the sugar **into carbon dioxide** and **alcohol.** The process of changing sugar in this manner is called **fermentation.** Most yeast cannot grow without sugar. The following experiment will prove that carbon dioxide is produced when yeast grows, while Section 79 will discuss the manufacture of alcohol.

Experiment 62.—Fermentation.

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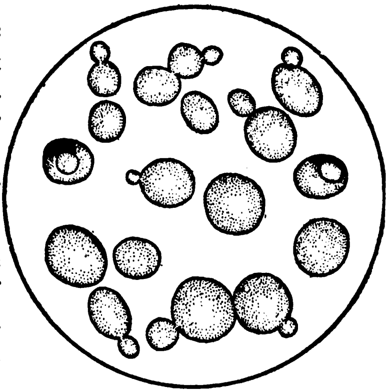
Apparatus: The apparatus may be as shown in the illustration on page 104, or a pickle bottle may be used in the place of the flask. A box may be used in the place of the ring stand.

Materials: Yeast cake, molasses.

a. Dissolve the yeast cake in a small amount of water and put it into the bottle which should be filled not more than one-third full of lukewarm water. Add two tablespoonfuls of molasses and shake well. Insert the stopple and place the tube in test tube which should be half full of limewater. In a few minutes bubbles will begin to come from the molasses and pass into the limewater. How do you know that the gas is carbon dioxide? Compare this experiment with Experiment 41.



While the first illustration of yeast shows the growth of a single yeast plant, it must be remembered that in a mass of yeast the plants will be found in all stages of growth. The illustration shows what would be seen if a small mass of yeast were examined under a very strong microscope. See Section 78.

50. Another Queer Kind of Plant—The Bacteria.

In several of our lessons we have read a little about the plants called **bacteria** and have learned that they grow fast in warm, damp places where the sun does not

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reach. We also learned that they may cause disease but that they can be killed by heat, bright sunshine and by antiseptic washes.

The bacteria are much smaller than the yeasts and can only be seen by the use of a very powerful microscope. They need moisture and a little warmth in order to grow, but they can live on almost any kind of food. Each increases in numbers very rapidly, if supplied with food, in a manner somewhat similar to yeasts. Instead of budding, however, each becomes longer and separates in the middle into two bacteria. This method of increase is called **fission**. Under favorable conditions a single bacterium will produce seventeen million bacteria in twelve hours.

Bacteria are the cause of many of the more delicate flavors of food. Thus butter and most kinds of cheese owe their peculiar flavor to the growth of bacteria. It is due to bacteria that the nitrogen of the air can be changed into food which is suitable for plants. See Section 31. There are also several beneficial changes in substances for which we must thank the bacteria. It is probable that there could be no life if it were not for the effects which are produced by bacteria. Thus we see that they are our friends.

Some kinds of bacteria are very harmful, and we should learn how to protect ourselves from them. Before studying how to preserve our health let us learn what the bacteria do to materials upon which they feed.

51. Souring and Decay.

When bacteria have been present in food for some time, they change it into substances which have bad odors and flavors. The food is spoiled and we call this

spoiling **decay**. If the bacteria had not been present there would have been no change at all in the food. So the bacteria spoil our food and thus are our enemies. If the only effect which the bacteria have upon food were merely to spoil it we would not have to take so much care of it. In addition to spoiling the flavor of our food and causing it to have a bad odor, the bacteria produce certain poisons, called **ptomaines**. The ptomaines may be formed to a degree sufficient to poison us without there being any disagreeable odor or flavor to the food. These poisons are very dangerous and we should be careful not to eat old food, or food which has remained long in a warm place. Cooking the food does not destroy the ptomaines.

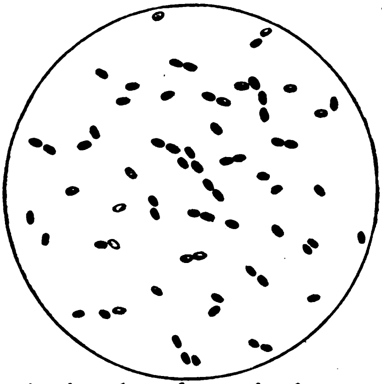
Another kind of bacteria changes cider and grape juice into vinegar. The mass of slimy material which is always found in vinegar, called **mother of vinegar,** is composed entirely of countless millions of bacteria. Vinegar is one of the class of materials which are called **acids**. You can always detect an acid by its sour taste. When milk sours it is because an acid has been produced in it by bacteria. In the following experiment on milk we can learn what is necessary to preserve food of all kinds.

Experiment 63.—How to Preserve Milk.

Apparatus: Can or dish in which to boil water, ring stand, burner, 4 test tubes or small bottles.

Materials: Milk, powdered borax, cotton, labels.

a. Label the test tubes No. 1, 2, 3, 4 and fill them one-half full of fresh milk. Set one aside, just as it is, in a warm place, put the second one in as cold a place as possible. To the third add a pinch of borax and set in



a warm place. The fourth tube should have a plug of cotton put into the top and then it should be placed in the can of cold water which should gradually be heated to 176°F. and kept at about that temperature for at least five minutes. This heating is called **pasteurization.** As soon as the tube is taken from the hot water it should be placed in cold water until cooled. Then set it in a warm place. Examine the milk once a day. Which tube sours first? Which keeps sweet the longest? If you have any doubt in the matter you may taste the milk. The illustration shows the kind of bacteria which caused the milk to sour. They are very much magnified.

Bacteria can be killed by heat and by poisons. The poisons are called **preservatives,** and they should **never** be used. The experiment was to show that poisons may preserve food but they are harmful and unnecessary. The growth of bacteria may be made very slow by keeping the food cold. Since bacteria require moisture in order to live, if the food is dried it may be protected from them. Smoking of meat and fish, as well as drying, will preserve them for a long time. Food may be kept moist and yet free from bacteria by the use of salt, sugar, or spices and vinegar.

After the bacteria, which are in or on the food, are killed by heat it is necessary to exclude others. This is

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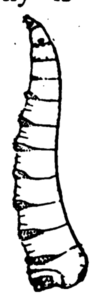
the reason for sealing preserves and canned goods. Why did you put the plug of cotton in the test tube of milk which you pasteurized?

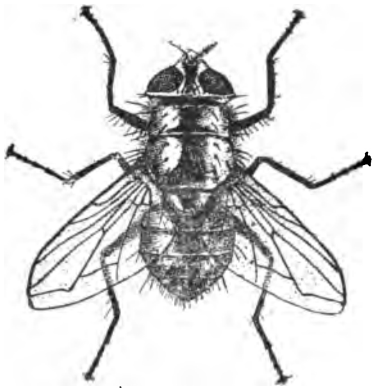
If we leave food upon our teeth the bacteria, which are always present, live upon this food and produce acids which hurt the covering of our teeth, called **enamel.** If this action continues very long the enamel is destroyed and then the bacteria of decay cause our teeth to decay. For this reason we should wash our teeth at least twice a day and always before going to bed. When the enamel is destroyed the repairs which a dentist may make are not lasting because the decay goes on around the filling which he puts into the tooth. Thus the hole or cavity becomes larger and larger until the tooth is destroyed.

52. Disease and Sanitation.

Some bacteria enter the body and, living upon the tissues, produce various diseases. All bacteria which enter the body are not harmful and some are helpful. Diseases which are given by one person to another by means of bacteria are called **contagious.** Flies are carriers of disease and the common house fly, which is shown magnified five times, is one of our worst enemies.

The life history of the common house fly is very





rapid. A single fly lays about one hundred and twenty eggs on the average, in manure and decaying material, which hatch within a day, producing maggots or **larvae.** The larvae or maggots go into the **pupal** or quiet stage after a few days, from which stage they come forth as flies in less than a week. The puparium is shown to the left of the illustration and the larva to the right. The other illustration shows a blue-bottle fly, also magnified five times. This fly is also called the meat fly, and breeds in decaying animal matter. All of these flies may carry disease. The common house fly should be called the typhoid fly as it is a carrier of that disease.

We should protect ourselves from the flies by screens, and do what we can to deprive them of foods. No decaying materials should be allowed anywhere in the yard or neighborhood. Horse stables should have a proper place for storing the horse manure until it can be carried away. Absolute cleanliness is a great preventive of flies. Sticky fly paper and fly traps will help to remove the flies which come into the house.

The diseases which are caused by bacteria are different from the poisons which the bacteria produce. The ptomaines act quickly while the diseases take several days, or perhaps weeks, in which to develop. The devel-

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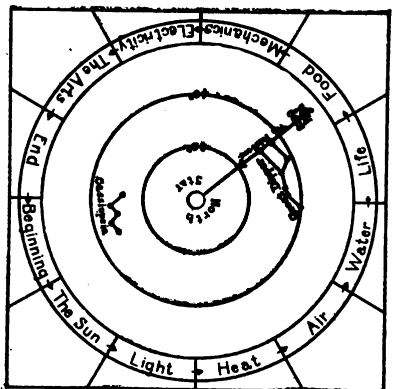
opment of a disease which is caused by bacteria is due to their growth within the body. If the body is in a good condition the bacteria will be overcome by forces within the body; it is usually a weak body which is easily attacked by bacteria. Thus the best way to prevent being sick is to take good care of the body. This means eating the proper food, sleeping enough and not doing anything which is harmful to the body. It means bodily cleanliness and clean houses. It means good ventilation, plenty of sunlight, and breathing fresh air both day and night.

Cleanliness, if complete, is the greatest help to **sanitation.** Sanitation means freedom from harmful bacteria.

Review Questions, 24.

1. What use is made of nitrogen?
2. Name all the sources of carbon dioxide we have studied.
3. What is the use of carbon dioxide?
4. What are the needs of all living things?
5. What is yeast? What can yeast do?
6. What are bacteria? Are all bacteria harmful?
7. How can you keep milk from souring? Which is the worst way and which is the best way?
8. Why should we clean our teeth at night when no one is to see them?
9. Why should we keep clean?
10. What is the best way to prevent being sick?

Next year we shall study more about plants and animals. Now we are going to learn about what plants and animals need for food and about the food which they make.


Mechanics
Electricity
The Arts
End
Beginning
The Sun
Light
Heat
Air
Water
Life
Food
North Star

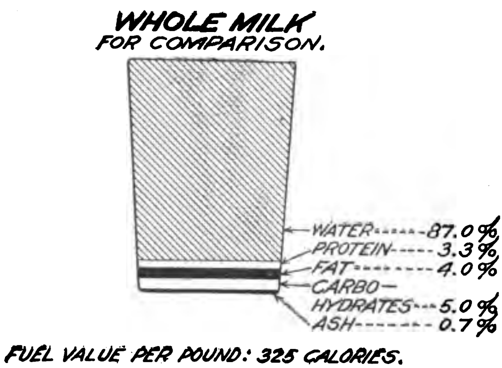
THE GUIDE

FOOD.

53. The Source of All Food.

The source of all of our food is the soil. Plants grow in the soil and, while they take in carbon dioxide through their leaves and nitrogen, after it has been changed by the bacteria, through their roots, they could not live if it were not for other material which is contained in the soil. This material is chiefly potash and phosphorus. Animals eat the plants and are used as part of the food of man.

Plant food and animal food are not very different in regard to the kinds of material which they contain. The difference comes in the proportions in which they occur. We need our food for three reasons: to give us



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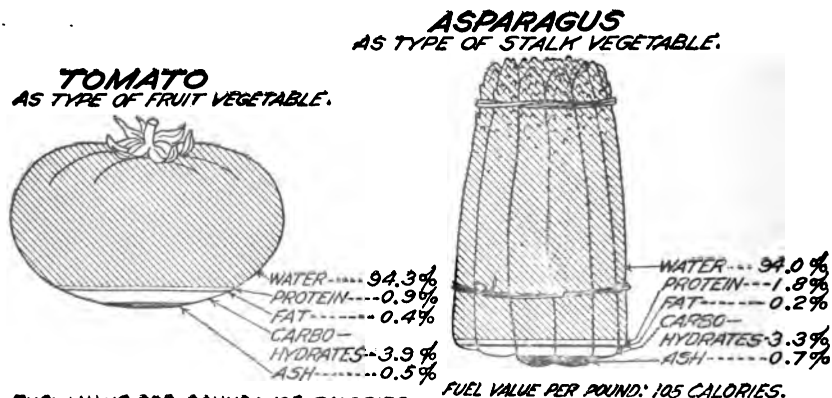
strength, to keep us warm, and to store up fat. The material which builds up the muscles and aids in the growth of new tissue is called **protein.** Lean meat and eggs are examples of food which contain a large amount of protein. Peas and beans are the vegetables which contain the most protein. The materials which are used chiefly for producing our animal heat are called **carbohydrates.** Grains, potatoes and other starchy foods, and all sugars are composed largely of carbohydrates. Some of the carbohydrates are transformed into fat. The fats, both animal and vegetable are used to produce fat in the body but they also produce a large amount of heat. Animal fats are butter, lard and the other fats which form a part of the meat which we eat. The amount of heat is measured by the **calorie.** A calorie will raise the temperature of one **liter** of water one degree Centigrade. A **liter** is the measure of liquids in the French system and is a little more than a quart. See Section 58.



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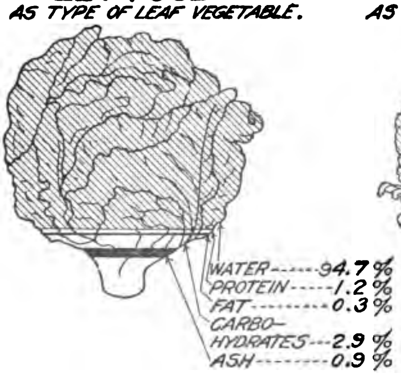
Milk is very nearly a perfect food. The illustration shows a glass of milk and the divisions indicate the different parts of the milk. Such a drawing is called a **diagram.** The other illustrations show some common vegetables. Note that there is more water in all of these vegetables than in milk This is true of nearly all vegetables and fruits, before they are dried. Notice also that vegetables have very little fat. For this reason they are good for summer food, as we need, and should eat very little fat in warm weather.

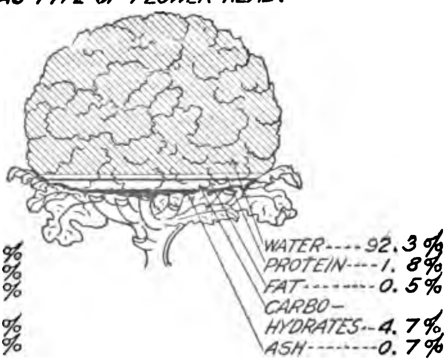
In Section 31 we learned that the bacteria took in the nitrogen from the air and changed it into food for plants, and that it was this food which if we ate it,

LETTUCE
AS TYPE OF LEAF VEGETABLE.



FUEL VALUE PER POUND: 90 CALORIES.

CAULIFLOWER
AS TYPE OF FLOWER HEAD.



FUEL VALUE PER POUND: 140 CALORIES.

would give us strength. Protein is the food which the plants make by the aid of the bacteria. So again we see that life would be impossible without our friendly bacteria.

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54. The Farm a Workshop.

For a long time people thought of the farm as a place where they could obtain something for almost nothing. All that they had to do was to plant seeds and reap the harvest. When it became necessary, however, to raise as large crops as possible, on account of the increased number of persons who had to be fed, people found that they must consider the farm as a workshop. Just as the materials are manufactured into the finished product in a workshop, so on the farm the food for the plants is made into vegetables and fruits.

In a workshop the supply of material, which is to be used to manufacture articles, must be kept in large quantities and the factories cannot produce the articles unless they have a proper supply of material. In the same way every plant that grows and every fruit or vegetable which is produced require a certain amount of plant-food. This plant-food is taken from the ground never to return. When all the plant-food has been removed by the growing plants, no more plants will grow in that soil. We say then that the ground is **sterile.** If we wish to change sterile land so that crops may be raised upon it, we must put into the soil the materials which plants require to make them live and grow. Such material is called a **fertilizer.**

A good farmer never allows his land to become sterile, but each year he adds to the ground the right kind of plant-food for the crop he wishes to raise. Now you see why a farm should be considered as a workshop—if you want a good crop you must either have in the soil those materials which the plants need or else you must

put them there. New land usually has a good supply of plant-food. Land which has been used for many years must have fertilizers added to it, if it is to produce good crops. Plant-food is chiefly phosphorus, potash, and nitrogen, although there are many other materials which are needed in small quantities.

All other kinds of business depend upon the farmers to whom we must look for our food of all kinds except fish. The farmer has opportunities in his business which are far greater than those found in other lines of work. He can, by experimenting, produce new fruits and vegetables, as well as improve those which we already have. He is a producer, that is, he gives to the world something which the world did not have before. Most of the other kinds of business take what has been produced from the earth and only make from it something which is of use. While all kinds of business tend to make the world a pleasanter place in which to live, the farmer is the only business man who actually makes the world richer for his labor.

55. Tilling the Soil.

When we consider the farm a workshop in which plant-food is changed into plants, and fruits, and vegetables, we must remember that plants require a large amount of water, and take care that they receive it. We learned in Section 48 that if rain fell upon bare ground that it would run off rapidly and wear the soil away. Where the land is level the run-off is not nearly as great as upon a hillside, but so much runs off that the soil does not receive enough to supply the needs of the plants. If

the ground is made rough and porous much more water will be absorbed than if the ground has been left smooth and hard. The loosening of soil so that it may catch the rain and prevent the run-off is called **tilling.**

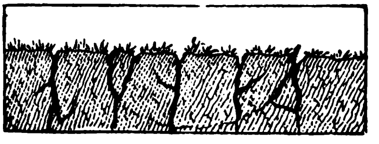
The first tilling, in preparing the soil for the seeds, exposes the under layers to the action of the air and also helps to bring more plant-food to the surface. Another necessity for tilling is to put the soil into such a porous and softened condition that the tender roots of the tiny plants may work their way into it. Porous soil also allows more air to enter it.

All tillage of the soil, after the seeds have been planted, is to kill weeds and to save the moisture which is in the soil. We have learned that water moves through the soil by capillarity and if we want to stop the movement we must close the holes. If you place some powdered sugar upon a cube of sugar, as shown in the illustration, and then touch the cube to some colored water (red ink) you will see the water rush up the cube but stop when it reaches the powdered sugar. Capillarity is good in the cube sugar but very poor in the powdered sugar. Try the experiment. We can do the same thing to soil by loosening the top of the soil and making it fluffy and

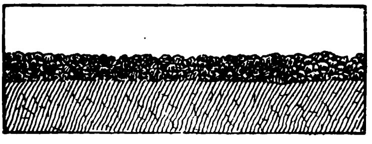
Cut supplied by the International Harvester Co.

powdery just like the powdered sugar. Such a layer of loose soil is called a **mulch.** It is only by mulching that the moisture can be kept in the soil. In those countries in which there is very little rain in summer the farmer is able to raise good crops by the proper amount of mulching.

The first illustration shows that soil which is not mulched cracks open and allows evaportion to take place far below the surface. Soil under such conditions will dry very



quickly and be of no use for farming. The second illustration shows soil which has been properly mulched and



the moisture preserved. It is very much like the cube sugar and the powdered sugar: the lower soil continues to bring up water from below, while the dry mulch prevents its loss when it comes near the surface. The soil must be mulched soon after each rain, as the water opens the pores of the former mulch and causes it to be of no use.

Tilling, as has been noted, kills weeds. This is accomplished by the tearing up of the weeds and saves a large amount of water. Weeds, like other plants, use vast quantities of water but they give no return to the farmer. Thus all the water which weeds use is a total loss to the farm. Weeds should be killed for other reasons, the chief one being that they are liable to kill the crops and their seed or stalks may spoil some crops.

Cuts supplied by the International Harvester Co.

56. Irrigation and Drainage of Farms.

It often happens, in lands of little rain, even if the soil is well tilled and the mulching well done, that there is not enough water in the soil for the proper needs of the crops. Under such circumstances it is necessary to add water to the farm from some river or well. Any addition of water to land is called **irrigation.** The soil should always be tilled as soon after irrigating as it becomes a little dry on top. Why?

Irrigation is of the utmost importance, since about two-fifths of the area of the United States is too dry for farming. Up to the present time a little over ten million acres are irrigated, which is very little compared with the dry area. Proper irrigation, that is, where there are several thousand acres to be irrigated, must be undertaken by the government, since it is impossible for any place to build a large irrigation system. Although the cost of irrigation is great, the large crops more than pay for it, and land, which otherwise would be a desert, blossoms into productiveness.

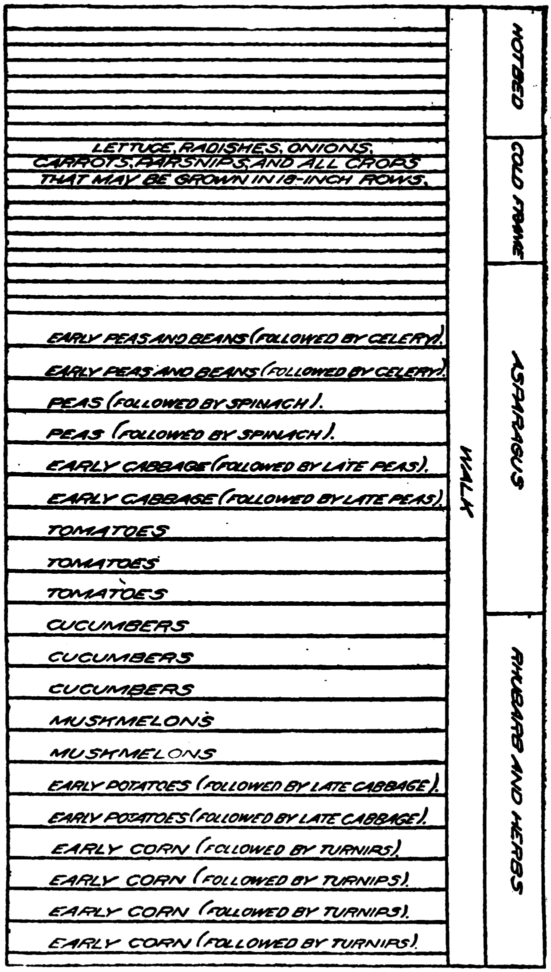
Sometimes there is too much water in the soil and it is necessary to remove some of it. This removal of water from land is called **drainage.** Drainage may be accomplished by ditches and by covered drain pipes which allow the water to enter at the joints. When the pipes are used the drainage is called **underdrainage.** Underdrainage is better than surface drainage as it keeps the water at the proper level and the plants send their roots deeper. Thus the plants have more soil from which to obtain their food and therefore they grow better. What is the harm of having too much water in the soil?

57. Gardening.

We have been learning about plants and their needs for some time as they are most important, since all life depends upon them. Their needs have been learned in the various topics under light, heat, air, water, and food. We have seen how the soil must be treated in order to supply the needs of the plant in the best manner, and to preserve the water which is in the soil. Now we should put our knowledge into practice, for that is its real test, and by experimenting we may strengthen our knowledge, and also increase it. This experimenting should be performed in the school garden, or in the home garden, or what is best of all, we should put into practice what we have learned about plants both in the school garden and in the home garden.

The selection of the place for the garden is very important. It should be near enough to the school to be convenient, and if the land has a slight slope toward the south it will be the best location for a garden in which to raise some of the early crops. Why sloping? Why toward the south? Having selected a good location what should be done to the soil before planting the seeds? The pulverizing of the soil should be done to a depth of at least six inches and eight inches would be better.

Even if the land has not been used as a garden in former years, it is better to put on some fertilizer at the same time as you are breaking up the top of the soil. The very best fertilizer is barnyard manure. A good way in which to apply the manure is to sprinkle a very thin layer of it on the soil and then work it beneath the surface with a spade or fork. Barnyard manure, in addition to being an almost perfect food for plants, has the great



Cut supplied through United States Department of Agriculture.

advantage of loosening the soil and making it more porous . Why is this an advantage? Many helpful bacteria which are found in barnyard manure also are added to the soil. If barnyard manure cannot be easily obtained a small amount of commercial fertilizer may be used.

You should always sow your garden seeds in rows. Straight rows make a garden appear neat. You can obtain a straight line by means of a tight string. Push a stick into the ground where you want to begin a row and tie a string to it. Go to the other end of the row, drive a stick and tie the other end of the string to it. Where did you use a tight string before? Rows should be about the same distance apart throughout their entire length. This can be accomplished by placing the two sticks at the two ends of the second row the same distance from where they were for the first row. How deep are you going to plant your seeds? After planting, the soil should be pressed gently down so as to fit closely around the seeds. This gives them the best chance of obtaining water and plant-food from the soil.

The care of the garden is chiefly to keep it moist, but not too wet, to remove the weeds, and to keep the upper part of the soil loose. Can you give the reason for each of these necessities? When the plants come up they should be thinned, that is, part of them should be removed if they are too close togther. Each plant must have room in which to grow and each one must have plenty of sun. Thinning may have to be done several times as the plants grow. While the sunlight is necessary, some plants, especially lettuce, may require to be shaded by boards, placed along the south side of the row,

and held in place by stakes which are driven into the ground.

The illustration gives a plan for a garden on a city lot, about fifty by ninety feet, and shows one method of following early crops with late crops. The plan will depend upon the locality. Full directions for planting will be found on each envelope of seeds. You have learned in general what to do, and you have also learned why you do it.

Review Questions, 25.

1. What effect has sunlight upon plants? How can you prove your answer?

2. Are there any plants, either large or small, which are harmed by sunlight? Is this an advantage to us or is it a disadvantage?

3. How can you prove that plants require heat in order to grow?

4. How do you know that plants need air? What part of the air do the leaves take in? What part of the air do the roots use? Can the roots take this part of the air without some help? Explain.

5. How do plants help man?

6. How do plants obtain the water which they need? What is the harm of too much water?

7. Do all plants grow in the ground? Explain.

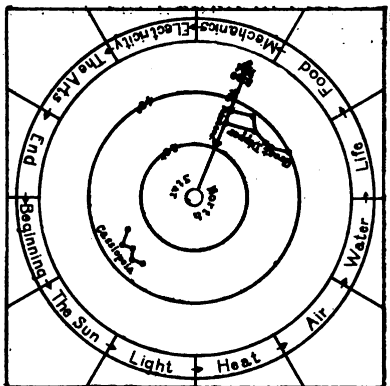
8. Tell about the harmful plants. What can we do to protect ourselves from them?

9. Name the three kinds of food material for man,

give some examples of each kind, and tell the use of each kind.

10. Explain how water can be kept in the soil. What is meant by 'dry farming"? Is the farm dry?

Thus far in our science work we have been learning about the necessities of life: now we shall study some of the things which help to furnish the comforts and conveniences of civilization.


Mechanics
Electricity
The Arts
Food
End
Life
Beginning
Water
The Sun
Air
Light
Heat
North Star
Great Dipper
Cassiopeia

THE GUIDE

MECHANICS.

58. Simple Measurement.

The first measurement we are interested in is that of **length.** We want to know how tall we are, how high a building or a mountain is, and how far it is to a certain place. When you say that you are four feet tall you mean that you are four times as long as the foot measure. You compare your length with this length which is twelve inches. The foot measure is your **standard** When you measure the length of a building you find how many times the twelve inches are contained in the length of the building. Thus you really divide the length of the thing you are measuring by the length of the standard. Where the comparison of two objects can be expressed as numbers the comparison is always division.

Our common standards of length are the **foot, yard,** and **mile.** Other countries have different standards, and we are gradually coming to use the French system. The chief advantage of the French system is that it is a decimal system. Thus 10 millimeters make a centimeter; 10 centimeters make a decimeter; and 10 decimeters make a meter. For most science work we use the **centimeter.** There are no eighths, sixteenths, and other divisions to bother us in our work. We do not have to remember that 3 feet make a yard, and that 5½ yards or 16½ feet make a rod. We are liable to forget the odd numbers and they are hard to multiply and divide. The

entire French system is decimal as we shall see later in our science.

The next measurement after length is **area.** Area is the surface of the thing measured and is found by multiplying the length by the width, if the surface has all right angles. How many degrees in a right angle? We express area in square feet, square yards, or square miles. We also have another standard called the **acre**. Can you tell how many square feet there are in an acre? Not an easy number to remember, is it? Many of our standards are not very convenient but we do not think much about them since we have always had them. It is only when we learn of a better method of doing something that we realize how much we have missed up to that time. The French acre, while it is about two and one-half times as large as our acre, is 100 meters long and 100 meters wide. This makes 10,000 square meters and is much more easily remembered than the number of square feet in our acre. For science work we use the small measure as in the case of length. It is the **square centimeter.**

Next after area is **volume.** Volume is the space occupied by a solid body or it is the space within a hollow body. The volume of a body having its sides at right angles to one another can be obtained by multiplying together its length, width, and depth. The result is expressed in cubical measure, such as cubic inches, cubic feet, cubic yards, and, in the case of wood, as cords. How many cubic feet in a cord? The French system uses the cubic meter. For ordinary science work we shall use the **cubic centimeter**. A measure like the

illustration, which is marked in cubic centimeters is called a **graduate.** This is intended for liquids.

When we are using the French system we should not compare it with the English standards which we use, but should take it just as it is, that, is, the same as a Frenchman would use it. However, in order to know what are the real values of the French units you should learn the following: 1 centimeter equals .39 inch, 1 meter equals 39.37 inches, and 1 kilometer or 1000 meters (the French mile) equals .62 mile.

Experiment 64.—Measurement.

Apparatus: Rule one foot long, marked in inches and sixteenths, and in centimeters and millimeters, rectangular pieces of cardboard of various sizes, cubical blocks of wood of various sizes, empty boxes of various sizes, which are water tight, graduate, several circular tin cans, string.

a. Find the length and width of a piece of cardboard in inches and sixteenths. Now find the area. Measure the same piece of cardboard in centimeters and millimeters. Put down the number of millimeters to the right of the decimal point. Now find the area. Which is easier to use, the French system or the English?

b. Measure another piece of cardboard, using the French system and compare its area with the area of the first piece. That is, divide the area of the large piece by the area of the smaller piece, carrying the number out to two decimal points. Now measure the second piece of cardboard in the English system and compare its area with the area of the first piece, also in the English sys-

tem. The answer should be nearly the same but there will be an error due to wrong measurement. You see it makes no difference what standards you use, for the real size of the body remains the same. Remember the two kinds of thermometers.

c. Find the volumes of two blocks of wood by using the French and the English systems. When you get through you will have no doubt in your mind which standards are the easier to use. Compare the two volumes. How much larger is one block than the other?

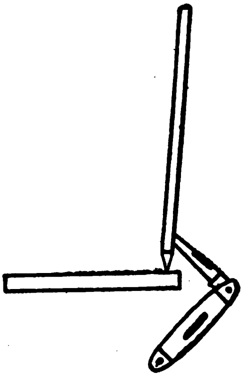
d. Find the volumes of two boxes, in the French system only. Compare the two volumes. Using the graduate, see how many cubic centimeters of water are required to fill each box. How do these amounts compare with the answers which you obtained by multiplication?

e. Measure the diameter of a circular tin can and multiply it by 3 1-7 and by 3.1416. Then measure the distance around the can with a string and compare the length of the string with your answer. Which is more nearly correct, the answer obtained by multiplying the diameter by 3 1-7 or by 3.1416?

59. Everything has Weight.—The Balance.

Whenever we try to lift any object we feel a pull which we must overcome if we are to move it. We call this pull toward the earth the **weight** of the object. We say that the **force** of **gravity** pulls the object and the earth together. In Section 63 we shall learn more about forces. The force of gravity pulls directly toward the center of the

earth, and unless an object rests upon something it will fall in that direction. If we wish to balance anything so that it will stand erect we must have either a large place upon which the object rests or we must have most of its weight below the place upon which it rests. The illustration shows you how you can balance a pencil upon its point by means of a knife. Explain the reason for this.

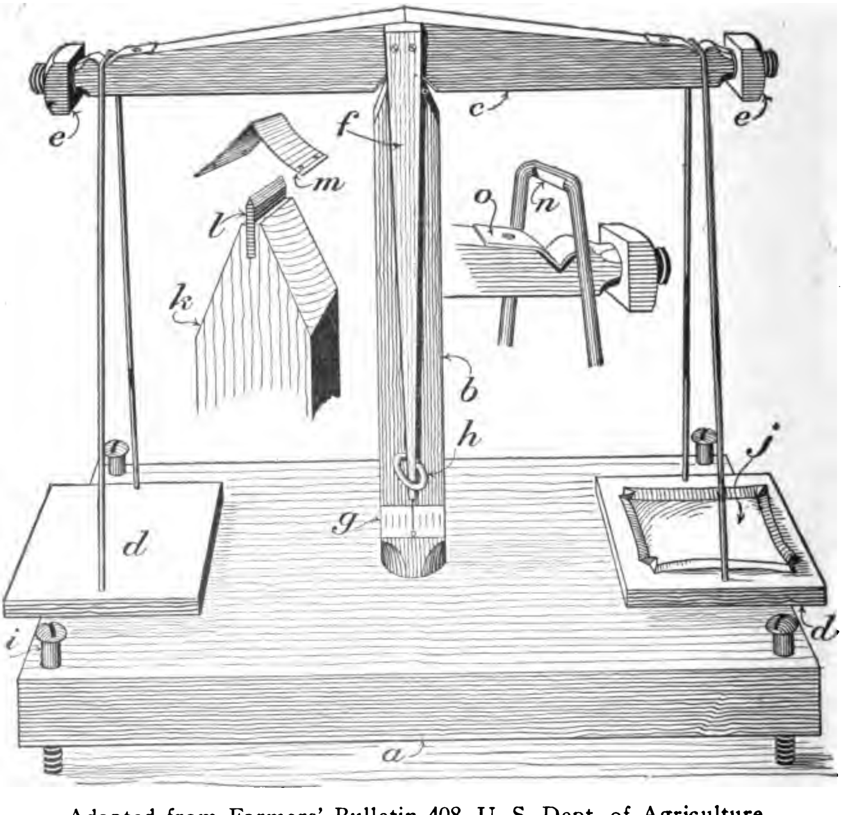


Since everything has weight, people have used weight as a method of measuring material, for a long time. Just as there are standards for length, area, and volume, so there are standards for weight. The common English standards are the pound and ton, and they have no special meaning. The French units are the **gram** and **kilogram** (100 grams) and mean something. The gram is the weight of one cubic centimeter of water at 4°C. and the kilogram is the weight of 1000 cubic centimeters of water at 4°C. This gives two ways of measuring water. It may be measured in a graduate or it may be weighed. The number of cubic centimeters and the number of grams will be the same. In the English system the weight of a cubic foot of water is 62.4 pounds at 4°C. There is no connection between any two parts of the English system and many different numbers must be remembered in order to change from one unit to another. The French system of weights is also decimal and there is nothing to remember. The weights are always expressed in parts of a kilogram or parts of a gram.

Experiment 65.—*Making a Balance and Weighing.

Apparatus: Hammer, saw, plane, bit-stock, bits ⅛″ and ¼″, sandpaper, file, pair of pincers, set of weights (French system).

Materials: Soft pine board ⅞″ thick, 12″ long and



Adapted from Farmers' Bulletin 408. U. S. Dept. of Agriculture.

Cut supplied through United States Department of Agriculture.

10″ wide, another board ¼″ thick, 10″ long and 4″ wide, two nuts having a half inch hole, screw eye, four ⅜ metal screws, iron or soft brass wire No. 12, pieces of tin, old knife blade, one dozen ⅛″ screws ⅝″ long, fine needle.

a. The illustration shows the balance as it should appear when finished. The base (**a**) is 12″x 7″, the pillar (**b**) is ⅞″ square and 9″ high, and is set in a ⅞″ hole in the center of base. The upper end of the pillar should be sharpened to an edge as shown at (**k**), and a slot sawed in it as shown at (l). The beam (**c**) is made from a stick ⅞″ square and 10″ long. Its lower edge is left straight but the other sides are planed so as to make the ends a little larger than half an inch square. The ends are then rounded so that the nuts (**e**) will screw on snugly. A notch 1″ wide and ½″ deep is cut in the center of the bottom edge. This receives the central bearing of the beam. An inch from each end of the beam a notch ¼″ deep is cut to receive the tray bearings (**n**). The two tray bearings, as well as the pillar bearing, should have the notches lined with tin as shown at (**m**) and (**o**). A pointer (**f**) made of ¼″ material, is firmly fastened to the beam by two screws. Its lower end is provided with a needle, colored black so as to be easily seen. The screw eye (**h**) is placed near the end of the pointer and in the center of the pillar. It should turn easily. When the balance is completed, turn the screw eye so as to hold the pointer firmly, then paste to the pillar back of the pointer, a strip of water paper (**g**), bearing scale marks 1-16″ apart, with the zero mark of the scale directly back of the needle.

The bearings of the balance are the most important

part of the instrument. The knife edge (l) may be made of a pocket knife blade or of a piece of hard brass filed to a straight sharp edge. The knife edges for the tray's bearings (n) are made by filing the under side of the tray wires where they cross the beam. The tray wires are made of No. 12 wire. The trays (d) are 3″x3″ and ¼″ thick. Two holes near the opposite edges receive the wires which should be bent in the opposite directions beneath the trays, thereby holding them firm and level. When the instrument is finished it may be made to balance, that is, the needle may be caused to move to, and remain at, the zero point, by moving the nuts on the ends of the beam toward the lighter side. The whole instrument may be made level and steady by means of the four screws at the corners as shown in the illustration, although this is not absolutely necessary. A paper box (j) may be used for small objects. The other tray must have an equal weight placed upon it and the instrument must be balanced before weighing any object.

b. Place the object which is to be weighed, upon the lefthand tray, and upon the righthand tray place a weight which is a little more than necessary. Then remove this weight and put on the next smaller weight. If this is too little, add the next smaller weight. Continue this until the instrument balances. The pointer must always swing free of the screw eye. If, instead of using the large weights first, the small ones were used there would be no small ones left to make the final balance. Always begin with the large weights.

60. Everything Occupies Space.

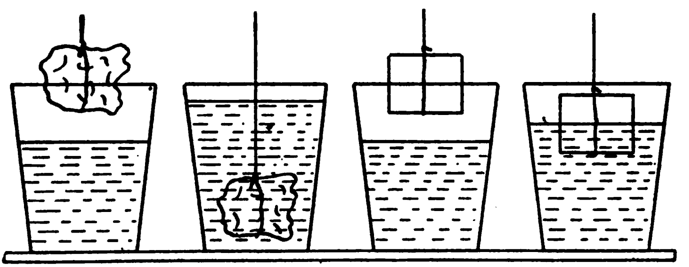
We have no doubt that solids and liquids occupy space and we would not try to put one solid in the space which another solid is occupying. Yet we might think that a solid could be placed in a liquid without forcing the liquid away, since the liquid does not always show that its surface has risen. Do you remember how the crow obtained his drink of water from the deep dish which had only a little water in it? Putting one kind of material in the place of another is called **displacement.**

It is very hard to realize that gases occupy space but they do, as we shall see in this experiment.

Experiment 66.—Displacement of Water by Solids and Air.

Apparatus: Two glasses, stone, block of wood, string, funnel, glass tube, rubber tube, large bottle or jar, graduate, rule.

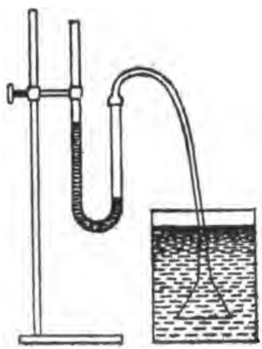
a. Note the level of the water when one glass is



about half full of water, and then lower the stone as shown in the illustration. What happens to the level of the water? Explain.

b. Repeat, using a block of wood. Do floating bodies displace any water? Do they displace as much as they would if they sank?

c. Measure the block of wood in centimeters and find how many cubic centimeters it contains. Then fill a glass completely full of water, place the glass in an empty jar, or in a deep saucer, and push the block beneath the surface of the water in the glass. The amount of water which overflows should contain very nearly the same number of cubic centimeters as you have just obtained from measuring the block. Measure the water carefully with the graduate and see how exactly you have performed the experiment. Now you can tell how to measure the volume of a stone or any irregular body. Explain.



d. Arrange the apparatus as shown in the illustration and push the funnel deeper and deeper into the water. Does the water go up into the funnel? Does air occupy space? Can you explain what happens in the bent tube?

61. Density.

People have long used the sayings "As heavy as lead" and "Light as feathers" without meaning just what they said. They really meant to say that a certain volume of feathers is much lighter than the same volume of lead. When we tell how much a certain volume of a material weighs we are giving its **density**. Since equal

volumes of feathers and lead do not weigh the same, people should say that lead has a greater density than feathers. How would a pound of feather compare with a pound of lead?

We are often more interested in knowing the density of materials than in knowing their weight. The density can always be obtained by dividing the total units of weight by the total units of volume,and is expressed as so many pounds per cubic foot, so many ounces per cubic inch, or so many grams per cubic centimeter, or, in fact, in any units of weight and any units of volume. Thus we say that the density of water is 62.4 pounds per cubic foot or nearly .6 of an ounce per cubic inch, or 1 gram per cubic centimeter. Which is the simplest expression?

Experiment 67.—Density.

Apparatus: Balance, set of weights, blocks of wood, pieces of stone, brick, lead, iron, zinc, or any kind of material weighing not over 200 grams; glass, large jar, graduate.

a. Weigh each object and make a record of the weights. Find the volume of each object by means of the displacement of water and record the volumes. Divide the units of weight of each object by the units of volume of the same object. This gives the density of each object.

How do your answers compare with densities which are given in the table? If they are not quite close, repeat using **other** pieces of the material.

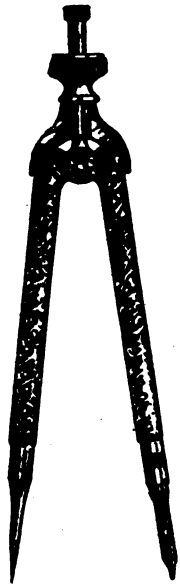
You should arrange your work as follows:

Name of object	Weight (in grams)	Volume (in cubic centimeters)	Density (grams per c. c.)
Aluminum	?	?	2.6
Bone	?	?	1.9
Brass	?	?	8.4
Cork	?	?	.24
Glass	?	?	2.5
Iron	?	?	7.7
Lead	?	?	11.3
Pine	?	?	.55
Stone	?	?	2.6
Zinc	?	?	7.

62. Drawings.

In all science work it is very desirable to illustrate the experiments, which you write up, by means of drawings. Drawing is like writing, since we use both to express on paper the ideas which we wish to keep in good form, but drawing is often a better means of expression than writing as it sometimes is impossible to write, or even explain by speech, some idea which we have. There are two kinds of drawing; that made without instruments, called **freehand** drawing, add that made with instruments called **mechanical** drawing. In science work mechanical drawing is used more than freehand drawing.

The chief instruments for mechanical drawing are the rule, square, triangle, and compass. A cheap kind of compass is shown in the illustration. The rule is used for making straight lines, the square for forming right angles, triangle for obtaining different slants or angles, and the compass for drawing circles or parts of a circle. All that you need in your science work is a rule and a compass. The longest distance across a circle is its **diameter** and the distance from the center of the circle to the outside of the circle is called the **radius.**



If you wish to make copies of your drawings the following experiment shows one method.

Experiment 68.—Blue Prints from Tracings.

Apparatus: Piece of window glass a little larger than the drawing which is to be copied, thumb tacks.

Materials: Tracing paper, blue-print paper.

a. Make the drawing upon any kind of paper and then cover it with a piece of tracing paper, fastening it with thumb tacks. Trace the drawing with a very soft pencil so that the line will be very dark. Use the rule and compass when tracing just as you would in the first drawing. After the tracing is made, place a piece of blue-print paper upon a board or book and lay the tracing upon it, right side up. Cover both with the piece of window glass and expose to the sun until the blue-print paper has become a bronze color. See Experiment

14 for full directions for the use of blue-print paper. Section 70 tells how to make blue-print paper.

Review Questions, 26.

1. How many hours of sunlight were there yesterday? How many hours without sunlight were there last night?

2. What is the direction of sunset now? How can you tell the direction of sunrise without seeing the sun rise?

3. What is a flame? Prove your answer. Why does charcoal burn without a flame?

4. What are some of the ways of keeping food from spoiling? Which is the worst method? Why?

5. Why is the farmer's occupation the most important? Explain.

6. What are some of the advantages of the French system of measurement?

7. Explain why it is better to use the larger weights before using the smaller ones in weighing.

8. When you blow through a tube into a liquid what is inside the bubbles? What does this show?

9. What is meant when it is said that the density of one body is greater than that of another body?

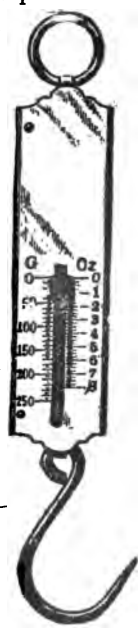
10. Besides talking and writing, how else can you express an idea?

63. Forces.

Any push or pull is called a **force**. Weight is a pull between the object and the earth and, as we have learned, is called the **force of gravity**. When we say that a body weighs five pounds we mean that the pull between the

body and the earth is five pounds. It would be necessary to pull the body, from on top, with a force of five pounds, to keep it from falling, or we could accomplish the same result by pushing the body from underneath. We have used a balance to find out the weights of bodies. In that case we compared the weight of an object with the weight of some standard. That is we compared pulls.

Some bodies move as a whole, that is, if one part is pushed or pulled so that it moves the whole of the mass moves. Other bodies, such as rubber and thin pieces of many kinds of material, may be moved in one part while the rest remains motionless. If we fasten a rubber band at one end we may move the other end a considerable distance without causing the fastened end to move. When the end, which has been moved, is released it will return to its former position. Bodies which act like this are **elastic.** Thin pieces of wood fastened at one end, may have the other end bent quite a distance to one side without breaking. The amount of stretching or bending depends upon the pull. If a weight of five grams bends the stick or stretches the rubber one centimeter, ten grams will cause a movement of two centimeters. This gives us another method of weighing.



Experiment 69.—Weighing by Elasticity.

Apparatus: Ring stand, spring from an old window roller, or some brass wire No. 20; rule, set of weights, spring balance as shown in the illustration, string.

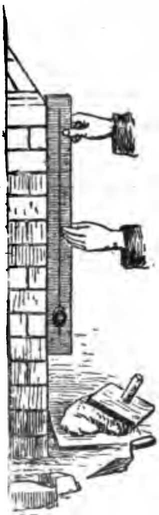
a. Fasten about six inches of the window-roller spring to a ring of the ring stand by means of string and bend the bottom turn of the spring into the form of a hook. Holding the rule against it, hang a ten gram weight upon the spring by means of string. How much is the spring stretched? Hang a twenty gram weight upon the spring and see how much the total stretch is. Repeat with the twenty and the ten together. Does the stretch vary with the pull? Does the spring always return to its first position when the weights are removed? If you cannot obtain a roller spring you may wind enough brass wire upon a round pencil to make a roll about six inches long.

b. Examine the spring balance. Are the division marks the same distance apart? Is this right? Explain. When you weigh anything on a spring balance what are you really measuring?

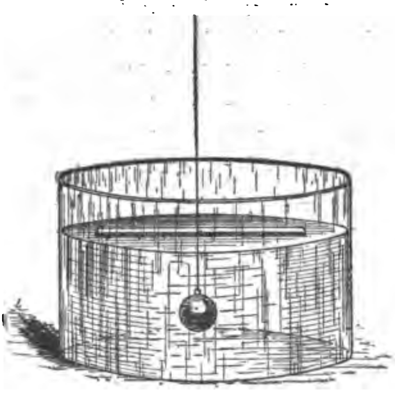
A pull tends to separate the parts of a body. We say we can pull something apart. A push tends to make the parts of a body closer together and we often speak of pushing things together. When we push the parts of a body closer together we say that we **compress** the body. Compression requires force and the force which is needed increases with the surface of the body. It takes more force to compress a body of three square centimeters of area than a body of one square centimeter of area, in fact it takes three times as much force. Yet the force for each square centimeter is the same in both cases. We call the force per unit of area **pressure.** The pressure needed to accomplish a certain compression is always the same for the same body, but the total force which is needed increases with the area.

64. The Plumb-bob and the Pendulum.

Since the force of gravity acts toward the center of the earth, and since a tight string makes a straight line, we can easily obtain a line, which if continued would pass to the center of the earth, by hanging a weight on the end of a string. This is called a **plumb-bob** and the direction of the line is called **vertical.** The name "plumb" comes from the Latin and means lead. This was the best material for plumb-bobs in olden times. We should make the wall of our buildings vertical and we can do it by using the simple method which is shown in the illustration.



As you have learned, the surface of water is level. Another name for level is **horizontal.** How many degrees are there between a horizontal line and a vertical line? Float a piece of wood upon some water in a dish and hang a plumb-bob in the water, as shown in the illustration. Then measure the number of degrees there are between the direction of the wood and the direction of the plumb-line. See Section 81.



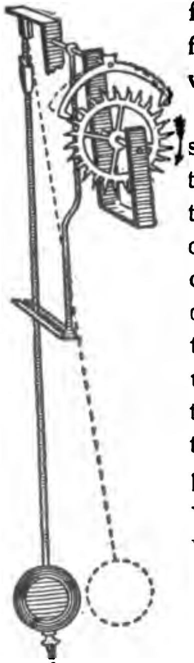
If we swing our plumb-bob we have a **pendulum.** You read in Section 8 that the

wheels of a clock are allowed to turn slowly by means of a pendulum. Now we are going to see why a clock can be regulated by the length of its pendulum.

Experiment 70.—The Pendulum.

Apparatus: String, stones of various sizes, rule.

a. Hang up a small stone by a string 25 centimeters long and count the number of swings per minute. Tie on a large stone in place of the small stone, keeping the length of the pendulum the same. Does the weight of the stone make any difference in the number of swings per minute? The time that it takes a pendulum to swing from one side and return again to its first position is called the time of **vibration.**



b. Hang up a stone, making the string 100 centimeters long and count the vibrations per minute. How does the number compare with the result obtained in (a) above? If you want a clock to go faster would you lengthen or shorten the pendulum? The illustration shows a clock pendulum. The pendulum is kept in motion by the push of the projections on the wheel, but the time is regulated by the length of the pendulum. Do you think that a clock would go faster or slower in hot weather? Explain. See Section 18.

65. The Lever.

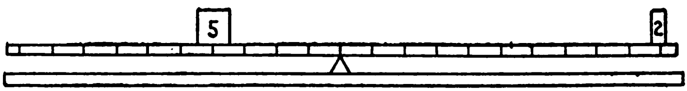
A stick, supported at a point between

its ends, is called a **lever.** The point of support is named the **fulcrum.** The advantage of the lever is to obtain a large force by the use of a small force. Let us learn by experimenting.

Experiment 71.—The Use of the Lever.

Apparatus: Long rule, or stick marked with equal divisions, triangular piece of wood to serve as a fulcrum, set of weights.

a. Arrange the apparatus as shown in the illustra-



tion. Does it balance? Multiply the smaller weight by its distance from the fulcrum and compare the result obtained by multiplying the larger weight by its distance from the fulcrum. It is not safe to draw your conclusions, or form an opinion from one experiment. Therefore place these two weights, and also other weights, at different distances from the fulcrum so that they balance and compare the products as suggested above. What are your final conclusions?

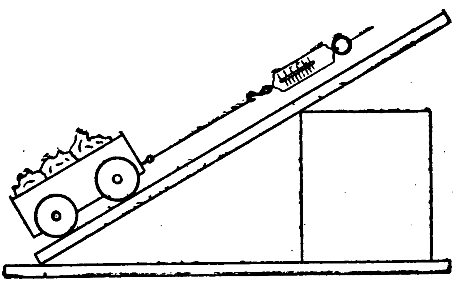
This experiment shows you how you can use a small force on the long arm of a lever and exert a large force on the short arm. Notice that the small force has to act a greater distance than the large force. You have seen men lift large rocks out of the ground by means of bars of iron called **crowbars.** You use a lever, or two of them,

when you cut cloth or use a **nutcracker. Where is the** easiest cutting **done, near the** fulcrum or at **the tip** of the **scissors**? If you want to crack **a hard** nut where in the nutcracker do you **place** it? The lever is called a **machine** since it enables man to use a small force to overcome a large force. It is the simplest machine we have and has been known for countless centuries. See Section 80.

66. The Inclined Plane.

Another machine which is very simple and has been known as long as, if not longer than, the lever is the **inclined plane.** This is simply a board with one end higher than the other. Instead of lifting a weight vertically it is pushed or rolled up the slanting board. Since the force acts a longer distance up the plane it is not as great as it would be if it acted only vertically. How is this like the lever?

Experiment 72.—The Use of the Inclined Plane.



Apparatus: As shown in the illustration, rule.

a. Find the weight of the car with its load of stones or weights. Find the force which is necessary to pull the car up the inclined plane. Which is greater?

b. Make the inclined plane steeper or less steep and find the pull necessary to pull the car up it. Measure the length of the plane and the height of the high end of the plane. Multiply the pull up the plane by the length of the plane and compare it with the result obtained by multiplying weight of the car, with its load, by the height of the end of the plane. Should you draw your conclusions from this? Finally draw your conclusions. Can you see any relation between the lever and the inclined plane?

A very common use of the inclined plane is made in splitting stumps. The inclined plane in this case is called a **wedge.** Instead of anything moving up the inclined plane the inclined plane, the wedge, moves and the material has to separate as the wedge is driven into it. The advantage is just the same as in the last experiment. Many other machines are very much like the lever and the wedge, although they are given other names. We shall learn more about machines next year, but it is most important to know just how these two aid us.

Review Questions, 27.

1. Why is the image of an object in a mirror right side up, but in a pinhole camera upside down?

2. What are the sources of heat and light? Can you obtain heat without light, or light without heat?

3. What is a porous body? Can it be changed so as not to be porous? Is there any advantage in having bodies porous? Name one very important porous body.

4. Name all the uses of water.

5. What should we do if we wish to keep in good health?

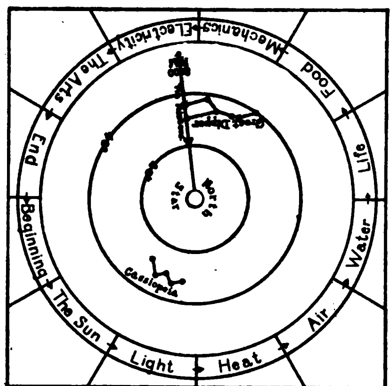
6. If a clock is going too slowly, what should you do to regulate it? Explain.

7. What is a force? What can forces do?

8. Name two ways by which you can exert a large force by using a small force.

9. What effect have forces upon elastic bodies? What use is made of this effect?

10. What are machines? What are the uses of machines?


Mechanics
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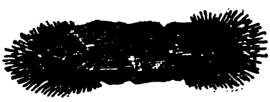
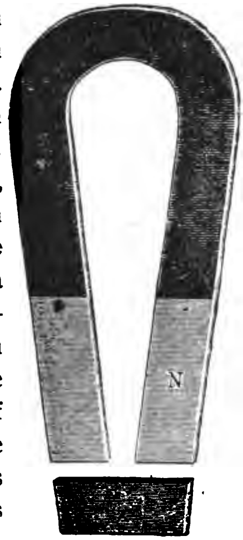
MAGNETISM AND ELECTRICITY.

67. The Lodestone.

There are two kinds of material which have the power of pulling bits of iron to them without first touching the iron. These are called **magnets.** There are **natural** magnets and magnets which have been made by man. The illustration shows a piece of natural magnet which has **attracted** iron filings to its two ends. Natural magnets are black stones and were first found near Magnesia in Asia Minor. A natural magnet is called a **lodestone.** The word "lodestone" means leading stone, for if a piece of lodestone is hung up by a fine thread, one end will point nearly north, and thus the lodestone will direct or lead us. The ends of the lodestone where the iron filings are the thickest, are called its **poles.** The poles are named **north** and **south** because one will point north and the other will point south. The poles of a magnet attract iron with greater force than any other part of the magnet. Lodestones are not important and are interesting only because they were the first magnets which were discovered by man, and their mysterious power has never been fully understood.



68. Steel Magnets.



Magnets which are made by man are called **artificial** and are much stronger than the natural magnets. All artificial magnets are made from steel. A straight magnet is called a **bar** magnet, while a straight bar, which has been bent into the form of a horseshoe, is called a **horseshoe** magnet. The illustration shows a horseshoe magnet. The chief advantage of this form is that both poles can pull upon or **attract** the same piece of iron. The piece of iron, which is shown across the poles of the horseshoe magnet, is called a **keeper.** It retains or keeps the magnet strong.

Experiment 73.—Magnetic Materials.

Apparatus: A bar magnet, pieces of every kind of material you can find, sheet of paper, thin piece of wood, piece of window glass and any sheet metal.

a. Try to pick up pieces of every kind of material with your magnet. What can you pick up with it? If you try to pick up a piece of tin with the magnet you must remember that "tin" is iron covered with tin. Iron is sometimes covered or **plated** with copper and brass. What are your final conclusions in regard to the kind of material which is attracted by a magnet?

b. See if the magnetism will pass through a piece of paper, thin wood or thin glass, or thin sheets of metal.

The space around a magnet, in which there is magnetism, is called a **magnetic field.** The magnetic field is strongest near the poles. The magnetic field may be drawn in the following way:

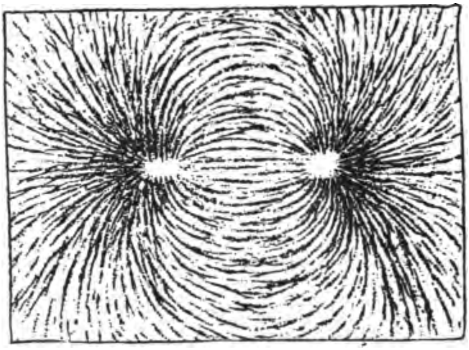
Experiment 74.—To Draw a Magnetic Field.

Apparatus: Bar magnet, iron filings in salt sifter.

Materials: Piece of paper.

a. Lay the magnet upon a table, cover it with the piece of paper, and slowly sift the iron filings upon the paper. They will take certain positions and they may be aided in arranging themselves by jarring the table a little. Draw with a soft pencil a large number of lines, following as closely as possible the lines which the filings are taking. After drawing the lines return the filings to the sifter.

b. Hide the drawing and make another drawing from memory. Then compare your two drawings and see what you have omitted. You should learn to draw a magnetic field from memory.



Just as you made blue prints of leaves and small objects, and copied drawings, so you can obtain blue prints of magnetic fields. The illustration gives one example of a magnetic field. You can make many.

Experiment 75.—Blue Prints of Magnetic Fields.

Apparatus: Two bar magnets, piece of window glass, iron filings in a salt shaker.

Materials: Blue-print paper.

a. Lay the two magnets upon a book, side by side, about the width of the magnets apart, having the two north poles pointing in the same direction. Lay a piece of blue-print paper upon the magnets with the yellow side up. Keeping in the shade, sprinkle iron filings upon the paper as in the last experiment. When the filings are nicely arranged cover them carefully with the piece of window glass, and place in the bright sunlight. When the paper has changed to the familiar bronze, return the filings to the shaker and immediately wash the blue print in water.

b. Repeat (a) above, but have the north pole of one magnet and the south pole of the other magnet pointing the same way. After the blue-print is made compare it

with the other blue print. Notice that the **lines of force**, as the filing are said to indicate, seem to push against one another in (a) and pull upon one another in (b).

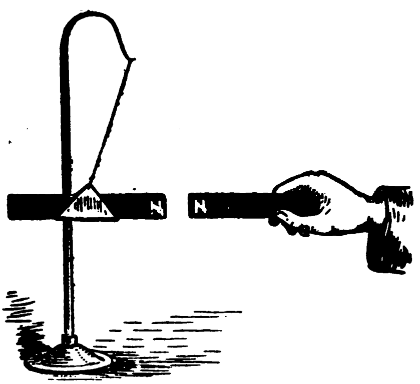
So far we have noticed that magnets attract iron. Now we are going to learn about the effect which two magnets have upon each other.

Experiment 76.—Attraction and Repulsion.

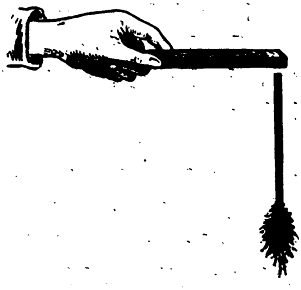
Apparatus: Two bar magnets, stand.

Materials: Thread, heavy paper.

a. Make a support for one magnet from the paper and hang it up by the thread, as shown in the illustration. The thread will untwist but the magnet will finally come to rest. Then bring up one pole of the other magnet to one pole of the supported magnet. What happens? The magnets have their north poles marked. Which poles caused the result? Now bring the other pole to the same pole of the supported magnet and tell what happens. As we have learned, if the poles come together it shows attraction; if they go away from each other we call it **repulsion**. What is the rule for attraction and repulsion?



The illustration shows an experiment which you should repeat for yourself. Take a nail and hold it near a magnet but not touching it. The nail will then attract iron filings. Remove the magnet and the nail loses its magnetism. Magnetism which is caused in this manner is called **induced** magnetism. Magnetism must be induced in an object before it can be attracted by a magnet. Since iron is the only common material which can have magnetism induced in it, it is the only common metal which can be attracted. Steel is made from iron and **retains** its magnetism better than iron because it is harder. Electricity can **produce** in iron much stronger magnetism than can exist in steel magnets. We shall learn about this next year.



Review Questions, 28.

1. What are the advantages of sunlight?
2. What is the proper method of heating water, from above or from below? Explain.
3. How do fishes live in the water? Do plants help fishes? Do plants help man? Explain fully.
4. Why do we eat? Why do we drink? When do we need to eat fat? When do we need to drink a large amount of water?
5. Name some plants which are harmful to man. What can we do to prevent these plants from harming us?

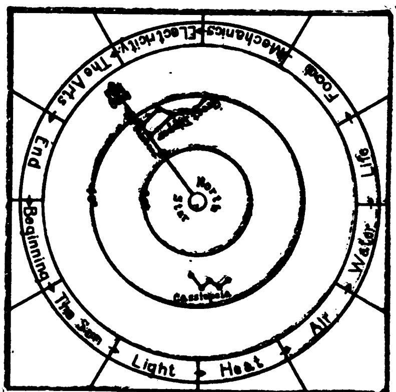
6. Name all the advantages of tilling the soil and tell how tilling may be accomplished.

7. What is a machine? Of what use is a machine to us? Name two simple machines and explain how they help us.

What are magnets? What are the two kinds of magnets? What is meant by attraction?

9. What are the poles of a magnet? How are the poles of a magnet different from the rest of the magnet? What are lines of force?

10. What is a keeper and what is its use? What is a magnetic field? What is meant by repulsion? What is induced magnetism?



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*THE ARTS AND INDUSTRIES.

69. Weather Observations.

The observation of the weather is valuable for many reasons. If we make observations regularly we get into the habit of keeping records of the observations in order to compare them with later ones. We soon learn that our memory is often weak and that records are to be trusted every time. The value of the records grows as they increase. Thus a record of the daily temperature for two years is much more valuable than for one year, while a record for ten years is of great value, especially in a farming district. Why? In the same way the record of the rainfall for several years helps the farmers, for they would not plant crops which require a very large amount of water in a locality where the rainfall is always small.

The records which you are beginning to keep will become a source of great pleasure to you as you gradually add more observations, and the record for each kind of observation increases with time. Begin by

* **Note to the Teacher:**—The scientific facts, upon which the following practical applications are based, have been studied in the preceding divisions. The great purpose of this division is to show that science is a matter of everyday interest and is of immense value to everyone alike. Since the principles have been stated in other sections these sections are necessarily shorter than those others.

arranging your records in orderly columns. As time goes on, the arrangement in columns permits an easy reference to past observations, and all the records of the same kind are together. The government of the United States is continually making records of the weather and these observations save millions of dollars every year to farmers and ship owners.

70. How to Make Blue-Print Paper.

While blue-print paper may be purchased at a small price, it is often desirable to prepare certain kinds of paper so that prints may be made on them. Another use of the mixture is to apply it to cloth. Simple cotton cloth soaked in it may be printed upon in the same manner as upon paper. A collection of prints of leaves may be made and the different pieces may then be sewed together to form a pillow cover. The solutions should be made as follows:

Solution A. Distilled water 125 cubic centimeters.*
Potassium Ferricyanide 25 grams.
Gum Arabic 2 grams.

Solution B. Distilled water 125 cubic centimeters.
Iron—ammonia citrate 37 grams.
Gum Arabic 2 grams.

Use equal parts of A and B, mixing them only in the dark. Candle light may be used. The two solutions are not affected by light until they are mixed. Paper which has no coating upon it should be used. The mixture may be applied in two ways—it may be poured upon the paper

* See Sections 58 and 59 for information in regard to measuring and weighing.

and the excess allowed to drip off, or it may be applied by means of a swab of cotton upon a little stick. The paper must be allowed to dry in the dark before being used. It is best not to prepare any more paper than will be used within a few days, as it spoils quite quickly.

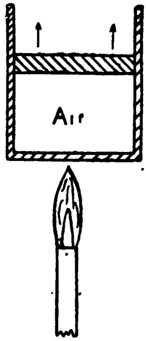
It is not necessary to cover the whole of a piece of paper if the print is to be a small one upon a large sheet of paper. Merely apply the mixture where it is needed.

71. Solar Heaters.

In Experiment 22 it was noticed that black and rough materials become much warmer in the sun than do other objects. Man has made use of this knowledge by making the sun warm water for him. If many feet of water pipe are painted black and exposed to the heat of the sun the water within them will become quite hot. This is a simple **solar heater.** The longer the pipe the more water can be heated at one time. Man has learned something else about the heat from the sun. If a box is made of wood, painted black inside, and covered with glass, the heat which is received from the sun can enter the box but cannot get out again as rapidly. Thus the temperature inside the box rises much higher than the temperature outside, if the sun is shining. Now if such a box is filled with many feet of water pipe, the water which is inside the pipe will become very hot. Such a heater on a sunny day can raise the temperature of water high enough for a hot bath. The water from a solar heater does not have to be heated very much in order to make it boil, so for cooking purposes it causes a saving in fuel.

72. Hot-Air Engines.

If air is heated it expands, as was learned in Section 18. This principle has been used to obtain power. The illustration shows a very simple hot-air engine. If a tube is closed at one end and has the other end sliding, which is called a **piston,** when the air inside is strongly heated by a Bunsen burner it will expand and force the piston out. After removing the burner the air will cool and contract and the piston will return to its first position. This is the principle of the hot-air engine but the usual engine has many more parts, and the hot air is exchanged for cold air instead of waiting for the hot air to become cold. You know now **why** the engine works. To learn just **how** it works will require further study after you have had more about machines.



73. Fireproofing.

Some materials burn much more easily than others and the same kind of material burns more easily if it is opened up to the effect of the air than if it is tightly rolled or compressed. The reason for this is, that if a body is porous the oxygen of the air can get at more of the material at one time and more burning or combustion can take place. Since this is so, if we wish to make some material less easy to burn we must put something upon it which will keep away the air from its surface. A solution which contains tin, or a solution of water glass, will accomplish this purpose quite well without harming the material.

It must be remembered, however, that nothing which can burn can be made really fireproof. If the temperature is raised high enough the material will burn or be destroyed, no matter what is upon it. Fireproofing serves to prevent easy burning and on that account is a very valuable process.

74. Waterproofing.

Many substances are more or less porous and allow water to penetrate them. As we learned in Experiment 46, water may be kept out of material by stopping the pores. In that experiment paraffin was used but there are other somewhat similar materials which may be used in the same manner. Thus if the pores of cloth are filled with rubber we obtain what we call rubber cloth. Oilcloth and oilskins are other examples of the filling of pores of cloth. The foundations and cellar floors of buildings may be made waterproof by covering them with melted tar, or tar paint; by asphalt, and by the addition of other matter to the concrete before it is mixed.

Another very interesting method is to have the pores, but treat the cloth in such a way that water will not readily enter. The following experiment shows the principle which underlies this method.

Experiment 77.—Waterproofing.

Apparatus: Burner, ring stand, wire gauze, tin dish, small glass tube, glass.

Material: Paraffin.

a. Insert the glass tube in some water in the glass and note how high the water goes by capillarity. See Section 41.

b. Melt some paraffin by gentle heat and dip the tube into it. Warm the tube gently until the paraffin is spread in an invisible layer up inside it, without stopping the hole. This makes the hole smaller and you might expect that the water would go higher in it. When the tube is cold place it in the water. Where is the surface of the water inside the tube?

This is the principle by which raincoats keep out the rain. The goods are porous but there has been produced a change in the threads so that capillarity has been destroyed. It is impossible to wet anything beneath the surface unless capillarity acts. Why do you wet a mop before using it?

75. Flavoring Extracts and Perfumes.

The making of flavoring extracts and perfumes are examples of solution by special solvents. In this case alcohol is the solvent. Vanilla extract may be made by grinding vanilla beans in a meat chopper and allowing the mass to soak in a mixture of one-half pure alcohol and one-half distilled water, in a stoppered bottle for several days. A small amount of sugar may aid the solution. This will produce a delicately flavored extract at a moderate price.

Grate off the outside of several lemons, or oranges, and soak the gratings for several days in pure, undiluted alcohol if you wish to make lemon or orange flavoring extracts at a slight price.

Many perfumes may be made by allowing the material, whose perfume is desired, to soak for several days in

pure undiluted alcohol. All of these solutions must be kept in tightly covered bottles as the alcohol will rapidly evaporate if the bottles are left unstoppered.

76. To Remove Grease Spots and Stains.

We may make use of both solution and capillarity for the removal of grease. In addition to the solvents which are mentioned in Section 36 there are ammonia water, naphtha, benzine, and ether for the removal of grease. All but ammonia water are very dangerous to use as they are so easily set on fire. Grease can also be removed by means of a hot iron. Place a cloth or blotting paper **under** the goods, cover the goods with a cloth or a piece of paper, and press with a moderately hot iron. The heat melts the grease and weakens the capillarity so that the grease moves **away** from the heat.

Ink spots may be removed by salt and lemon juice if the spots have not become dry. Red ink may be removed by ammonia water. Paint may be removed by turpentine and benzine. Tea and coffee stains may be removed by cold water and glycerine if allowed to soak for several hours. Enameled sinks and bathtubs may be cleaned with kerosene, followed by hot water and soap.

77. How to Make Soap.

There are two kinds of soap — hard and soft. In olden days, before soap became so common and so cheap, soapmaking was one of the household arts. Then there was much soft soap made as it was easily made and convenient to use. Now hard soaps of various kinds have nearly driven this art from the home.

Soap is a combination of grease and lye. Caustic potash and grease make soft soap, while caustic soda and grease make hard soap. The kind of grease which is used makes the soap high grade or low grade; toilet soap or laundry soap.

Experiment 78.—Soap Making.

Apparatus: Burner, ring stand, tin can.

Materials: Lard, sodium hydroxide (caustic soda), salt.

To 85 cubic centimeters of water in the tin can add 15 grams of sodium hydroxide and 40 grams of lard; boil slowly ten minutes. Be very careful that the mixture does not spatter upon you. After boiling add about 25 grams of salt and continue to boil for five minutes. Then allow all to cool and remove the soap which will be on top. Let the cake dry for several days, and then see if it will produce suds.

78. Bread Making.

There are several kinds of bread but they can all be placed in two classes—bread raised by baking soda and bread raised by yeast. In all cases the bubbles are formed by carbon dioxide. In Experiment 48, (d), we saw that baking soda and cream of tartar, when mixed in solution, produce carbon dioxide. The cream of tartar should be mixed dry with the flour, and the baking soda dissolved in a little water, if they are to accomplish the most good. Why? In Experiment 63 it was shown that baking soda, when added to sour milk, makes it sweet. At the same time carbon dioxide is produced by the action of the acid in the milk upon the baking soda.

This explains why sour milk can be used with soda for pancakes or griddle cakes. Should the baking soda be added to the milk or should it be dissolved in a little water and added to the mixture after the sour milk has been stirred in? Explain.

When bread is made yeast is added to make it "rise." The yeast uses the sugar which is added to the mixture, and some of the flour is changed to a kind of sugar which the yeasts can use. Carbon dioxide is produced which forms the bubbles and thus the dough swells and becomes porous and tender. Most of the alcohol bakes out. Why is bread made with warm water during the cold weather? Another use for yeast is in the making of homemade root beer. The stopples "pop" when the bottles are opened on account of the large amount of carbon dioxide which the liquid contains.

79. Alcohol for Industrial Purposes.

Alcohol may be made from any vegetables or stalks of crops, which contain starch or sugar, by means of yeast. This means that much of the waste in crops due to small vegetables or some damage which renders the vegetables unfit for sale may be turned into alcohol which is very valuable for many of the arts and industries. Alcohol is used in large quantities as a solvent, and it is also used for lighting, heating, cooking, and for running engines.

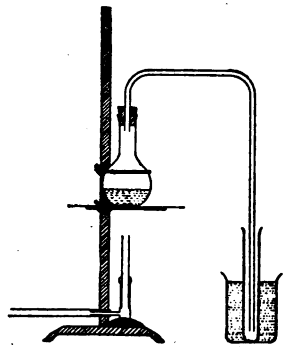
The United States Government has removed the tax on alcohol if it is not to be used as a drug or drink. The only requirement is that something must be added to the alcohol which will render it unfit for persons. Alcohol in this condition is called **denatured.**

Experiment 79.—Making and Distilling Alcohol.

Apparatus: Burner, ring stand, wire gauze, flask, tin grater, glass tube, test tube, glass.

Materials: Molasses, potatoes, yeast.

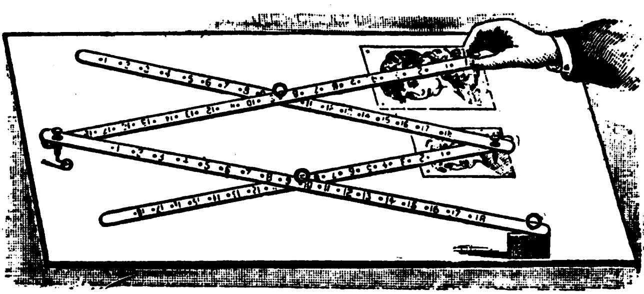
a. Experiment 62 may be repeated and the fermentation allowed to continue for three days. Then arrange apparatus as shown in the illustration and warm the mixture very gently. Alcohol will pass off just before the boiling temperature of the water is reached and will collect in the tube which is placed in the cold water. The alcohol should burn when poured upon a plate and touched with a match.



b. Grate some raw potatoes, mix with water, and add about one-tenth as much yeast as there is mash Allow to ferment as in (a) above, and distil.

80. The Pantagraph.

The pantagraph, as shown in the illustration is a

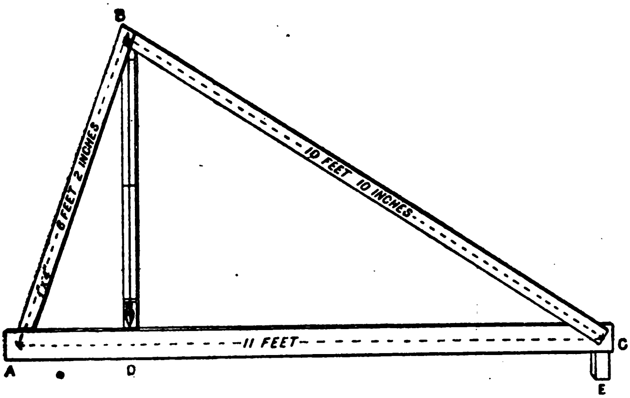


practical application of the lever, and is used to enlarge drawings or to make them smaller. It is made from four long, thin sticks which have holes, at regular intervals, in which pegs may be inserted. The block on the right hand lower corner is fixed to the table. All the rest of the pantagraph is free to move. The point under the hand does not mark; the point over the smaller picture is a pencil. The little wheel at the left of the pantagraph is not necessary but allows it to move more freely. By moving the point over all the lines in a drawing an exact copy is made by the pencil only the new drawing is smaller in this case. To enlarge a drawing the non-marking point is placed where the smaller picture is, and the pencil is placed where the hand in the picture now is.

When studying the lever you learned that the small force moves a longer distance than the large force. The pantagraph may be considered as four levers all acting together. A certain motion of one part will make a larger or smaller motion of another part according as the lengths of the arm are changed by changing the pegs. Make a pantagraph and copy some drawings.

81. Levelling.

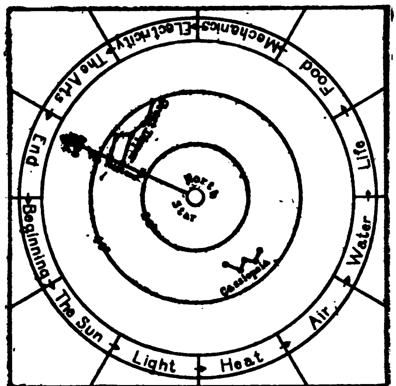
It is very often desirable to know how to make level the foundations of a building. The illustration shows a very simple method which has been used for many years. The apparatus is made of the size as shown. The plumb-bob hangs from (**b**), and the plumb-line is kept from swinging too much by some wide staples. To adjust the apparatus rest the two ends upon two stakes driven



into the ground, driving in the high stake until the plumb-line is about in the middle of the board (**bd**). Then mark just where the point of the plumb bob comes. Reverse the apparatus upon the stakes, without changing them and mark where the point of the plumb-bob comes. Exactly halfway between the two marks is the proper place to put the level mark. When the apparatus is placed so that the plumb-bob comes to this mark the bottom stick is level.

Sometimes a certain slant is wanted, as when ditches are being dug to carry water. In this case a block is placed at (**ce**), having a length according to whatever **drop,** as it is called, is wanted for each eleven feet. Then the apparatus is used as in levelling, but instead of being level the ground has the slant which is desired.

Cut supplied through United States Department of Agriculture.


Mechanics
Food
Life
Water
Air
Heat
Light
The Sun
Beginning
End
The Arts
Electricity
North Star
Cassiopeia

THE GUIDE

APPENDIX.

REFERENCE BOOKS ON BIRDS.

Farmers' Bulletins:

No. 54. Some Common Birds.
No. 493. The English Sparrow as a Pest.
No. 506. Food of Some Well-known Birds.
No. 513. Fifty Common Birds of Farm and Orchard.

Finley, W. L., American Birds, Scribners.

REFERENCE BOOKS ON FLOWERS.

Farmers' Bulletins:

No. 28. Weeds; and How to Kill Them.
No. 86. Thirty Poisonous Plants.
No. 188. Weeds Used in Medicine.
No. 195. Annual Flowering Plants.

Going, M., Field, Forest, and Wayside Flowers, Baker and Taylor Co.

REFERENCE BOOKS ON TREES.

Farmers' Bulletins:

No. 134. Tree Planting on Rural School Grounds.
No. 173. Primer of Forestry. Part 1.
No. 358. Primer of Forestry. Part 2.
No. 423. Forest Nurseries for Schools.

Mathews, F. S.. Familiar Trees, Appletons.

LIST OF APPARATUS AND MATERIALS.

The numbers indicate the first experiments in which the apparatus or the material is used. The amount needed will depend upon the number of pupils but, as will be seen, the expense will be slight.

1. Sticks, 3′x½″x½″.
   String.
2. Rules, 12″—30cm.
   Scissors.
   Dividers.
   Cardboard.
   Paper rivets.
   Pins.
3. Nails, assorted.
   Odd pieces of board.
5. Protractors.
   Hatpins.
8. Bottles, assorted.
   Files, triangular.
   Cork stoppers.
   Glass tubing, ¼″.
   Sand.
10. Thumb tacks.
    Chalk boxes.
11. Window glass.
    Candles.
12. Knives.
13. Colored cloth, assorted.
14. Blue-print paper.
16. Library paste.
17. Mirrors, 2″x4″.
    Rubber bands.
    Block of wood, 2″x2″x4″.
18. Drinking glasses.
19. Kerosene lamp.
    Kerosene.
    Bunsen burners.
    Alcohol lamps.
    Alcohol.
    Test tubes, 6″x¾″, 8″x1″.
    Test-tube holders.
    Iron Wire, No. 28.
    Soft coal.
24. Argand or student
20. Some article with luminous paint on it.
22. Spice cans.
    Paper, asorted colors.
23. Glass lenses,3″ diam. chimneys.
    Iron wire No. 18.
24. Argand or student.

25. Unequal expansion apparatus.
Salt.
26. Cheap thermometers.
27. Ring stands with three rings.
Wire gauze, 5″x5″.
27. Circular tin cans, assorted.
28. Blocks of wood, 2″x4″x6″.
Wooden rods, 7″ long, 1″ diam.
Lubricating oil.
29. Friction gaslighters.
30. Turpentine.
Pieces of broken chinaware.
31. Charcoal.
Pieces of various combustibles.
33. Baking soda.
Bandages.
Limewater.
Olive oil.
34. Copper rods, No. 12, 6″ long.
Iron rods, No. 12, 6 long.
37. Wing tops for Bunsen burners.
38. Saucers or shallow dishes.
39. One 20-oz. bottle.
Medicine droppers.
Phenolphthalein, ¼oz.
40. Potassium chlorate.
Manganese dioxide.
41. Glass funnels.
Syringe bulbs.
Glass jar, 6″x8″.
Rubber tubing, 3-16″ hole.
42. Gallon bottle.
Large pan to hold two gallons.
43. Pie tins.
Small round bottles with stoppers.
Levels, ($.20).
45. Balances, (can be made).
Set of weights, 500 g.
Sponges.
Stones.
Pieces of bricks.
46. Paraffin.
47. Filter paper, 5″.
Sawdust.
48. Tin spoons.
Sugar.
Cream of tartar.
Ammonium chloride.

49. Gasolene.
    Lard.
    Rosin.
    Pitch, or some tree gum.
50. Beakers, 200 cc.
    Alum.
    Copper suphate.
51. Powdered or shaved soap.
52. Beans.
53. Very small glass tubing, assorted.
    Lamp wicks.
    Red ink.
    Cube sugar.
54. Cake pans.
    Gravel.
    Loam.
    Cheese cloth.
56. Blotting paper.
    Seeds of beet, corn, pea, etc.
57. Wooden tray, 12″x12″x2″.
58. Larke pickle bottles.
    Black cloth.
59. Paper in sheets 17″x11″.
60. Labels.
61. Seeds of apple, pear, orange, lemon.
62. Molasses.
    Yeast.
63. Powdered borax.
    Absorbent cotton.
64. Graduate, 50 cc.
65. Materials etc. for balance.
69. Spring balances, 250g.—8 oz.
    Window roller springs.
71. Triangular pieces of wood.
72. Little car for inclined plane.
73. Lodestone.
    Bar magnets.
    Horseshoe magnets.
74. Pepper boxes.
    Iron filings.

Section 70.
    Potassium ferricyanide, 1 oz.
    Iron-ammonia citrate 1½ oz.
    Gum Arabic, ¼ oz.
78. Sodium hydroxide.
79. Tin vegetable grater.
    Potatoes.

OTHER BOOKS BY THE SAME AUTHOR

General Science Outline. Published by Cunningham, Curtiss, and Welch. (Out of print.)	
Introduction to General Science, with Experiments. A text for the first year of high school. Published by the Macmillan Company -	Price, 75 cents, cloth net,
Outline of Science for the Fifth Grade. Published by Percy E. Rowell, Berkeley, California -	postpaid Price, 10 cents, paper
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